















ANALYSIS OF STATE TRANSPORTATION AGENCY METHODS  
FOR DETERMINING CONTRACT DURATIONS

THESIS  
S2201

BY

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A REPORT PRESENTED TO THE GRADUATE COMMITTEE  
OF THE DEPARTMENT OF CIVIL ENGINEERING IN  
PARTIAL FULFILLMENT OF THE REQUIREMENTS  
FOR THE DEGREE OF MASTER OF ENGINEERING

UNIVERSITY OF FLORIDA

SPRING 1988





To Anne, for her never-ending patience and support.



## ABSTRACT

The primary purpose of this report was to analyze the various methods used by state transportation agencies for determining contract time. The analysis consisted of a discussion of the various considerations and ramifications of highway construction contract time determination, and an examination of the various procedures followed by state agencies across the country in determining contract durations with the use of survey information received. For the purpose of this report, contract time was considered to be synonymous with contract duration.

Evaluation of survey responses revealed that for the majority of cases, there are four basis for which contract time is determined: construction season limits, quantity or production rates, work-flow techniques, and estimated costs. Most commonly it was found that a combination of two or more of these are used to determine contract durations. These findings were in close agreement with those discussed in Transportation Research Board Special Report 79, Contract Time Determination.

With the belief that the use of productivity rates plays an important role in determining highway construction contract durations, special attention was given to methods





involving these rates, with a comparison made of work item productivity rates from several states. A comparison of these rates is found in Appendix A.

Based on analysis of the various methods used by state transportation agencies in determining contract time, this report proposes that, with the exception of large, complex projects, simple bar charts be used for this endeavor. A step-by-step approach to this method is outlined in the final chapter of this report.



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## CHAPTER I

### INTRODUCTION

#### A. Background.

An essential ingredient in any highway construction contract is the amount of time allowed to complete the work. Because of the increasing complexity of modern highway construction projects, the nature of the contractual relationship between contractors and public agencies, and the desirability of timely completion, sound engineering judgement and careful planning is critical in establishing the contract time for a project.<sup>1</sup> Considerable time and effort is devoted by many state transportation agencies towards setting reasonable highway construction contract durations, because each day of work beyond the project completion date generates proportional costs for the agency, the road user, and the general public.<sup>2</sup>

Because most present-day highway construction projects are directed more towards the improvement of existing roadways rather than the construction of new ones, the affects of close working conditions, traffic interruptions,





conflicts with existing structures and utilities, and political and regulatory encumbrances must all be taken into consideration when determining contract durations. It is these considerations that agencies are responsible for acknowledging when determining contract time allowed for project completion.

Because of the repetitious nature of work items involved in highway construction, one would think that the methods used in determining contract durations would be quite similar from one state to the next, but upon investigation, it is found that many methods, and combinations of methods, are used across the country. The degree of complexity and effort range from conceptual time estimating to a detailed critical path method (CPM) analysis of the project. Techniques that rely on individual judgement contrast with those that draw heavily on historical data accumulated by an agency.

#### B. Objective.

The objective of this report was to first discuss the various considerations and ramifications of highway construction contract time determination, and then analyze the various procedures followed by state agencies across the country in determining contract durations with the use of survey information received. Comparisons were made, and conclusions and recommendations offered on their use.



With the belief that the use of productivity rates plays an important role in determining highway construction contract durations, special attention was given to methods involving these rates, with a comparison made of work item productivity rates from several states. A comparison of these rates is found in Appendix A.



CHAPTER II  
RESPONSIBILITIES AND CONSIDERATIONS  
IN DETERMINING CONTRACT TIME

A. Highway Construction.

Highway construction is unique from most other categories of construction in that it is very equipment and field material oriented. Projects of this type are characterized by large numbers of power shovels, tractor-scrapers, pile drivers, draglines, large cranes, heavy-duty haulers, paving plants, rock crushers, and associated equipment types.<sup>3</sup> This class of construction covers such things as clearing, excavation, fill, aggregate production, subbase and base, paving, drainage structures, bridges, traffic signs, lighting systems, and curb and gutter.

Because most highway construction differs very little from one contract to the next in comparison to most other types of construction, it lends itself most readily to planning and scheduling efforts that can be depended upon. It is this repetitiveness that aids state agencies in determining construction contract durations.





## B. Defining Contract Time.

Before an evaluation of the methods of determining contract durations can be approached, the actual definition of contract time should be defined. Not surprisingly, this definition varies from state to state and from contract to contract. Contract time can be based on an estimated number of working days or calendar days or on a specific completion date, which may be established by computing working days or determined by external influences.<sup>4</sup> The American Association of State Highway Officials defines calendar days and working days as follows:

*Calendar day.* Any day shown on the calendar beginning and ending at midnight.

*Working day.* A calendar day during which normal construction operations could proceed for a major part of a shift (Saturdays, Sundays, and holidays are usually excluded).

Controlling items, or items of work that are large in volume, require lengthy periods of time for completion, or are on the critical path of a precedence diagram are usually the basis for charging a work day.<sup>5</sup> Typically, working days are charged to a project when conditions for more than one-half of a normal shift is suitable for work. This varies, however, as several agencies often charge only fractions of a day.



A calendar-day contract is not necessarily the same as a specific completion date contract. Contracts of these types may or may not include provisions for guaranteed work days or a specified number of days per month. The most common types of contracts used by state agencies across the country are completion-date contracts, with or without a guaranteed number of working days. The following completion-date contract specifications were derived from several states<sup>6</sup>:

*Completion date (specific). The contractor must have all (essential) work completed by a specific date without regard for working days.*

*Completion date (guaranteed working days). The contract completion date can be extended if the contractor has not had available the number of working days as stated in the contract. Either the number of working days for each month or the total number of days for the contract period may be stipulated.*

The North Carolina DOT Standard Specifications defines contract time as: "The number of calendar days inclusive between the date of availability and the completion date, said dates being set forth in the special provisions, including authorized extensions to the completion date."



### C. Determination, Review, and Approval Procedures.

Direct responsibility for determining contract duration varies from state to state depending generally on the method used in establishing contract time limits. If the procedure used is the critical path method, or something on a similar level, design team personnel within a transportation department typically prepare the first estimate which is then reviewed by the department's construction division. If experience or construction seasons are the basis for determining contract durations, construction unit personnel will usually have the responsibility for setting the time limits.<sup>7</sup>

Regardless of who the individuals might be that determine contract duration, it is of utmost importance that a construction data file be maintained for such items as production rates, time, weather effects, job conditions, etc. over the previous 3 to 5 year period for all jobs. The determination of reasonable contract durations can only be expected with the use of reliable historical data.

In Florida, the determination of contract duration is performed at the district level by the District Estimates Engineer during the design phase of a project; this is then reviewed by the District Construction Engineer.<sup>8</sup> Contract durations in some agencies are set by the district office with the approval of the headquarters' design or construction section (see Figure 2.1). The headquarters



level of other agencies set contract durations with districts having input on major or critical projects. Minor projects in these cases might go directly to the contract office (see Figure 2.2). A chart showing the procedure for determining contract time in Georgia is shown in Figure 2.3.<sup>9</sup>

#### D. Factors Effecting Contract Time.

The contract time set by an agency may require some adjustment because of external factors that affect the construction progress or necessitate the completion of a facility by a specific date. These include<sup>10</sup>:

- Coordination requirements
- Commitments
- Effects on road users and others, and
- Financial requirements.

#### Coordination Requirements

One important coordination requirement involves staged construction. Because delay in completion by one contractor may result in claims for delay by a subsequent contractor, some contracts or portions of contracts must be completed by a specific date. In these cases, it is often best to make use of a specific-date type contract with a high rate of liquidated damages rather than a working-day or calendar-day contract. Using the latter methods can







quite easily result in follow-on contractors being put at a disadvantage due to relatively minor delays incurred by the first-stage contractor such as delays caused by weather or material shipments. Additionally, because it is the state agencies that determine working days available, it is they that are most vulnerable to claims as a result of late contract completion by an earlier-stage contractor.

Another common requirement in coordination involves the delivery of materials. Bituminous materials, cement, and other essentials necessary in road construction that are most vulnerable to shortages during peak construction periods can cause serious contract delays. One way to handle the problem is to schedule completion so that the critical stages will be completed before shortages develop. In some cases, contracts for major structures are awarded separately at earlier dates in order to ensure that materials are delivered on time.<sup>11</sup>

Some of the most difficult coordination requirements an agency might face are those that involve other events such as the coordination of the completion of a transportation facility with urban renewal, the opening of a major shopping center, construction of a utility or railroad project, or other special events.<sup>12</sup> As with staged construction, specific completion-date contracts with sufficiently large amounts of liquidated damages are best suited for this type of construction.



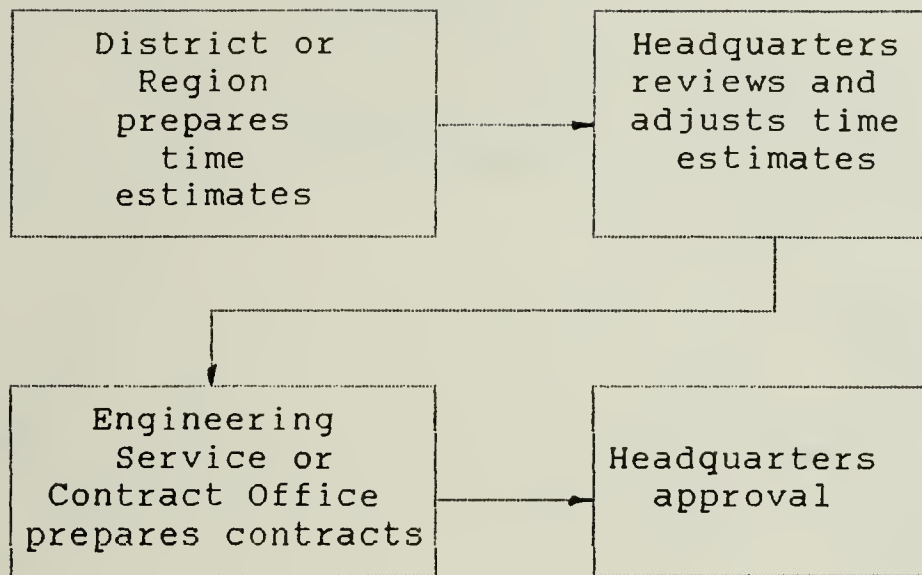


Figure 2.1 Contract Time Determination and Review Originating at the District Level.

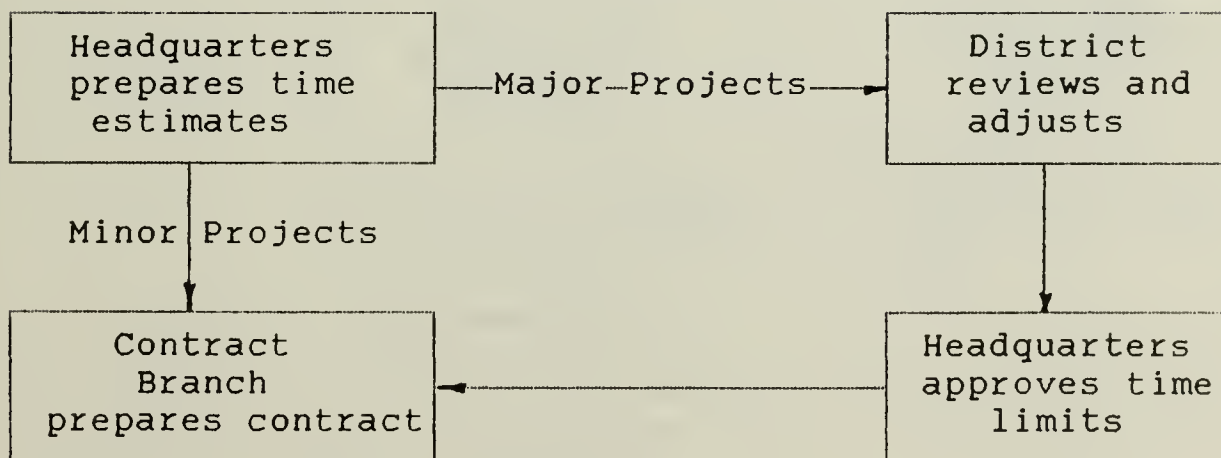


Figure 2.2 Contract Time Determination and Review Originating at the Headquarters Level



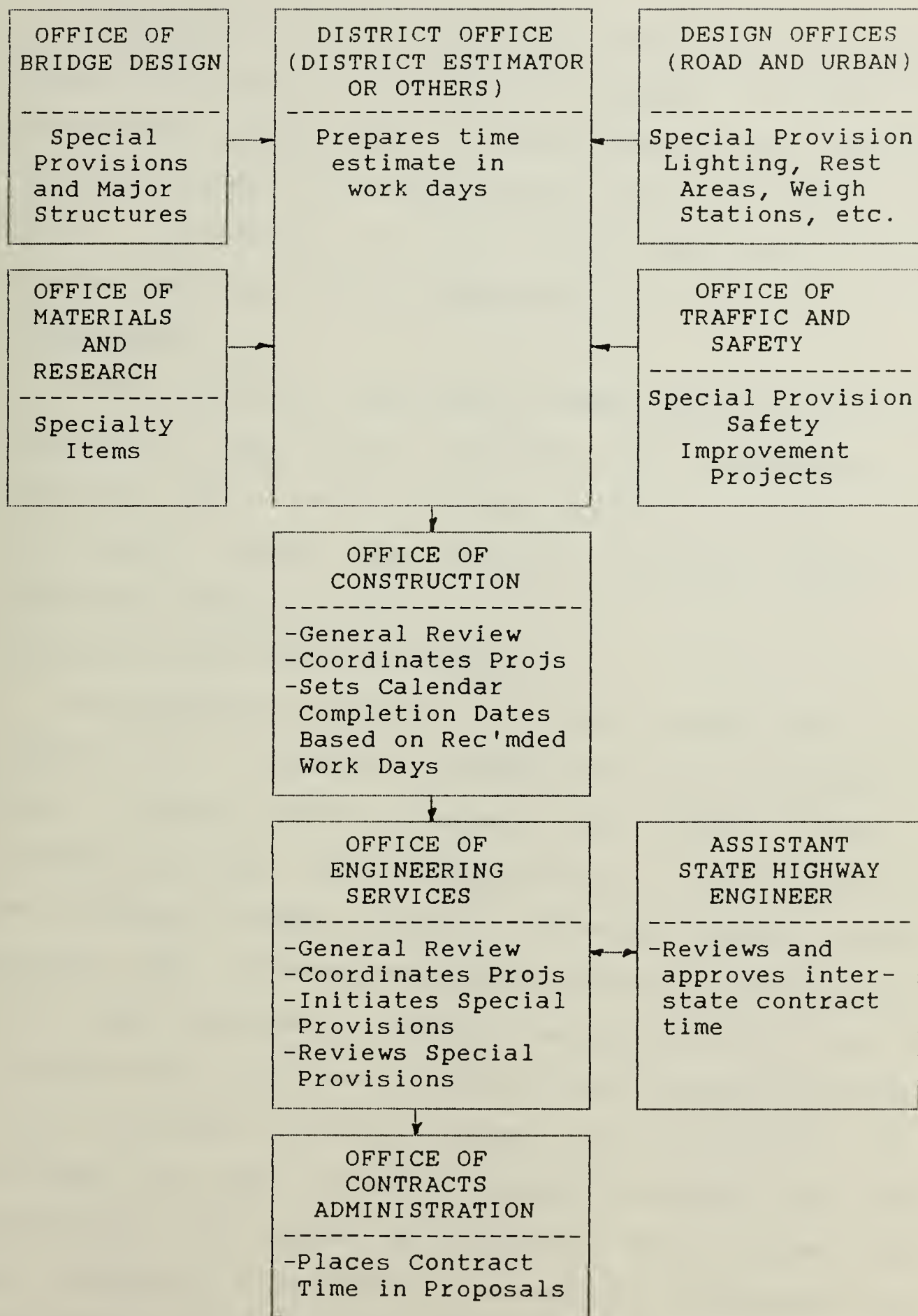


FIGURE 2.3 Procedure for Determining Contract Time (Georgia).



Without proper coordination, contract delays may be encountered due to utility work delays. Avoidance of unnecessary street cuts or other utility work that often follows highway or street paving can be realized with proper attention given to the coordination between transportation and utility departments.

#### Commitments

State agencies occasionally make commitments to local governments that certain projects will be completed by a specified date. Because of the pressure to fulfill these commitments, these type contracts generally specify a mandatory completion date.

#### Effects on Road Users and Others<sup>13</sup>

The demands of traffic in urban areas have caused agencies to be extremely careful when setting completion dates. High traffic volumes can greatly delay a contractor's work, and at the same time, construction work can seriously impede traffic. A lengthy detour around a project will generate considerable costs in terms of time, fuel, and maintenance. Travel on a project site that is hindered by construction delays also increases road-user costs in terms of time, safety, and convenience. The increase in such costs is largely affected by field conditions, the degree of completion of the project, and the adequacy of provisions for traffic maintenance and protection. On the other hand, if a contractor were to





initiate double shifts to complete a project by an unreasonable date, greater exposure to hazards and traffic disruptions might result than would occur with the expeditious continuation of work with moderate use of overtime. Therefore, establishing a tight, optimum completion time cannot be justified in all cases solely by road user costs.

Roads under construction generally have a detrimental impact on business and abutting property owners, even when contract provisions have been included to cover this situation. However, once the roadway and driveways are paved, the impact of minor completion work is generally negligible. For this reason, it may be desirable to assess working days and liquidated damages on one level when traffic or access is disrupted and assess them on a smaller level for failure to complete minor work on time.

#### Financial Requirements

State financing and budgeting personnel across the country are mixed on their feelings towards the importance of precise computation of contract duration for purposes of budgeting. Some agencies feel that there are too many other factors affecting the expenditure rate for this to have any significance, while others feel that contractor payments and contract time are major factors in predicting cash flow.



Engineering manpower and supervision costs are also important considerations when establishing contract durations. The conservation of these costs may be realized with proper planning on the part of state agencies.

E. Working-Day Time Charges.

An agency's policy for making time charges and granting extensions naturally has a direct effect on the completion of construction projects within the allowed contract time. If an agency expects its calculations in determining contract durations to be predictable, it is essential that the charging of time on all contracts be consistent and reasonable. When lenient policies are followed on some projects and more harsh policies on others, time and effort devoted towards establishing reasonable contract durations may be wasted. As discussed above, controlling or major work items identified by the agency are generally the basis for charging time on a project. Another key consideration is the amount of time in which the work may be completed.

Several factors which effect the amount of working days charged to a construction project are left to the discretion of the project engineer. Typically these include adverse weather conditions, material shortages, delays in material deliveries, and labor problems. Factors that generally receive automatic extension of time on a



contract, or result in possible working days not being charged include agency delays, additional items of work, quantity overruns, utility adjustments, coordination with other contractors, scheduled public events, or delays caused by things such as fires, floods, war, or sovereign acts of government.

The effect of adverse weather on a project can be difficult to determine. Large projects may encompass various sites that may experience slightly different weather conditions. Additionally, an evaluation must be made as to whether or not controlling items of work have been effected by the weather. Where cold temperatures might halt pavement striping, they would probably have minimal or no effect on work items such as guard-rail placement, except in the case of frozen ground. Accurate documentation of weather conditions on a daily basis is essential in avoiding later arguments and claims by the contractor that weather conditions were not favorable enough to allow work on particular days.

When there is an unforeseeable shortage of material beyond the control of the contractor, general practice is to not charge resulting delays as working days. Unless there is an industry wide shortage in which an agency would already be aware of the situation, the contractor is responsible in providing documentation to the agency proving that the delay was beyond his control. This



documentation may include a letter from the manufacturer or vendor stating the reason for the delay along with the date that the contractor ordered the material.

Sometimes, when determining contract durations, agencies fail to take into consideration long lead times necessary for the fabrication and delivery of some materials required on a project. If a contractor can show that he placed an order in a timely manner with a reputable supplier, the fabrication and delivery times for that material are reasonable, that the material couldn't have been supplied sooner by any other available supplier, and the delivery of these materials causes a delay, then the delay is generally not charged against working days.

Labor problems incurred by a contractor which create shortages or cause delays are generally given due consideration by most agencies, even on completion-date projects. Labor strikes involving a contractor's employees would result in delays that would be easily calculable, however, the influence of strikes remote from the work area which might hinder a necessary supply of material to the project, although harder to determine, should also be considered when charging time.

Right-of-way and access problems that delay the start or continuation of a controlling work item are agency-caused delays which are considered sufficient justification for not charging work days to a project. In fact, the







Supreme Court of Montana has ruled that an agency's delay in furnishing a highway right-of-way was a breach of contract for which the Montana State Highway Commission was liable.<sup>14</sup> Other agency caused delays might be the result of design changes or errors in field work on the part of the agency. In any case, agencies are generally quite liberal when charging work days or granting time extensions when the reason for the delay was due to their own actions or inactions. In today's litigious society, this policy is normally deemed prudent as agency delays may result in liability for such things as<sup>15</sup>:

- Overhead expenses of the contractor and subcontractors (for both home offices and field offices) attributable to the delay.

- Equipment costs for each additional day equipment must remain on the site.

- Escalation in labor costs due to increases in wage rates during the delay period.

- Direct costs of delay including such items as extra labor.

- Labor inefficiency where scheduling is disrupted owing to the delay, and the work forces are not used at normal efficiency.



#### F. Liquidated Damages.

It has become almost standard practice to include contract provisions for liquidated damages in construction contracts. Such provisions have been found valid by the courts as a method of compensating a party, in this case an agency, for costs and delays incurred when a project is not completed within the contract time specified. This is considered by the courts as a breach of contract.

The main benefit to the contractor of liquidated damage provisions is the avoidance of subsequent claims for damages. If a contract does not contain a liquidated damages provision, the contractor is liable for actual damages it causes by its delay. Liquidated damages are used in lieu of a determination of the actual damages suffered.

*In order for an agreement fixing the amount of damages made in advance of a breach to be enforceable as a contract it must be shown that (a) the amount so fixed is a reasonable forecast of just compensation for the harm caused by the breach, and (b) the harm that is caused by the breach is one that is incapable or very difficult of accurate estimate [Barr & Sons, Inc. v. Cherry Hill Center Inc., 217 A.2d 631 (N.J. Super. Ct. 1966)].*

In the event that the requirements stated above have not been met, for example when damage amounts are deemed excessive or unreasonable, liquidated damages provisions



may be considered penalty clauses which are unenforceable. In this case, an agency would either receive nothing or the recovery would be limited to actual damages incurred.

The items most often considered when estimating amounts of liquidated damages are<sup>16</sup>:

- Additional costs of engineering, administration, etc.,
- Loss of time,
- Increased operating costs and safety for facility users, and
- Damage and inconvenience to adjacent property owners.

Typical schedules for liquidated damages in relation to original contract amount are shown in Figure 2.4.<sup>17</sup> Use of these type schedules simply reduces the effort required when preparing contract specifications. As can be seen, rates vary from contract to contract.

#### F. Incentive Payments.

One way in which agencies can keep the amount of construction time to a minimum is to include incentive clauses in the contract. Such provisions provide for a bonus for each day of early completion and liquidated damages for late completion. When used, bonus payments are usually equal to the benefit of early completion. A



### SCHEDULE OF LIQUIDATED DAMAGES

| Original amount of contract |           | Per diem Amount of |         |
|-----------------------------|-----------|--------------------|---------|
| For more                    | To and    | Liquidated Damages |         |
| Than                        | Including | Calendar Day       | Workday |
| \$ 0                        | \$ 25,000 | \$ 30              | \$ 42   |
| 25,000                      | 50,000    | 50                 | 70      |
| 50,000                      | 100,000   | 75                 | 105     |
| 100,000                     | 500,000   | 100                | 140     |
| 500,000                     | 1,000,000 | 150                | 210     |
| 1,000,000                   | 2,000,000 | 200                | 280     |
| 2,000,000                   | -----     | 300                | 420     |

\* Calendar day amounts are applicable when the contract time is expressed on the calendar day or calendar workday or fixed date basis.

### Schedule of Deductions for Each Day of Overrun in Contract Time

| Original Contract Amount |            | * Daily Charge |       |
|--------------------------|------------|----------------|-------|
| From More                | To and     | Calendar       | Work  |
| Than                     | Including  | Day            | Day   |
| \$ 0                     | \$ 25,000  | \$ 30          | \$ 42 |
| 25,000                   | 50,000     | 50             | 70    |
| 50,000                   | 100,000    | 75             | 105   |
| 100,000                  | 500,000    | 100            | 140   |
| 500,000                  | 1,000,000  | 150            | 210   |
| 1,000,000                | 2,000,000  | 200            | 280   |
| 2,000,000                | 3,000,000  | 300            | 420   |
| 3,000,000                | 5,000,000  | 500            | 700   |
| 5,000,000                | 7,500,000  | 750            | 1,050 |
| 10,000,000               | 15,000,000 | 1,500          | 2,100 |
| 15,000,000               | 20,000,000 | 2,000          | 2,800 |
| 20,000,000               | 25,000,000 | 2,500          | 3,500 |
| 25,000,000               | 30,000,000 | 3,000          | 4,200 |
| 30,000,000               | 35,000,000 | 3,500          | 4,900 |
| 35,000,000               | and over   | 4,000          | 5,600 |

\* The daily charge shall be made for every day shown on the calendar beyond the specified completion date; and, when the time limit is specified as working days, the daily charge shall be made for each additional working day, computed as specified in Article 108.04.

Figure 2.4 - Typical schedules for liquidated damages.





Charge for liquidated damages for each day of delay

| Original contract price |                      | Calendar Day or<br>Specified<br>Completion<br>Date | Working Day |
|-------------------------|----------------------|--|-------------|
| From more<br>than-      | To and<br>including- |  |             |
| \$ 0                    | \$ 50,000            | \$150  | \$210       |
| 50,000                  | 100,000              | 250  | 350         |
| 100,000                 | 500,000              | 400  | 560         |
| 500,000                 | 1,000,000            | 500  | 700         |
| 1,000,000               | 2,000,000            | 600  | 840         |
| 2,000,000               |                      | 700  | 980         |

LIQUIDATED DAMAGES. Unless otherwise provided in the contract, liquidated damages will be in accordance with the following schedule:

| Original Contract Amount |                     | Daily Charge |
|--------------------------|---------------------|--------------|
| From<br>More Than        | To And<br>Including |              |
| \$ 0                     | \$ 25,000           | \$ 30.00     |
| 25,000                   | 50,000              | 50.00        |
| 50,000                   | 100,000             | 75.00        |
| 100,000                  | 500,000             | 100.00       |
| 500,000                  | 1,000,000           | 150.00       |
| 1,000,000                | 2,000,000           | 200.00       |
| 2,000,000                | -----               | 300.00       |

Schedule of Liquidated Damages for  
Each Day of Overrun in Contract Time.

| Original Contract Amount |                     | Daily Charge                  |          |
|--------------------------|---------------------|-------------------------------|----------|
| From<br>More Than        | To and<br>Including | Calendar Day<br>or Fixed Date | Work Day |
| \$ 0                     | \$ 25,000           | \$ 30.00                      | \$ 42.00 |
| 25,000                   | 50,000              | 50.00                         | 70.00    |
| 50,000                   | 100,000             | 75.00                         | 105.00   |
| 100,000                  | 500,000             | 100.00                        | 140.00   |
| 500,000                  | 1,000,000           | 150.00                        | 210.00   |
| 1,000,000                | 2,000,000           | 200.00                        | 280.00   |
| 2,000,000                | 4,000,000           | 300.00                        | 420.00   |
| 4,000,000                | 7,000,000           | 400.00                        | 560.00   |
| 7,000,000                | 10,000,000          | 550.00                        | 770.00   |
| 10,000,000               | -----               | 700.00                        | 980.00   |

Figure 2.4 (continued)



provision of this sort is normally used only for projects that are time-critical.

This concept is also sometimes referred to as "reverse liquidated damages,"<sup>18</sup> whereby damage amounts for both owner-caused delays and contractor-caused delays are stipulated in the construction contract. An advantage to the agency when using this type of provision is that a ceiling is placed on the amount of damages that can be demanded by the contractor for agency-caused delays.

In a survey of state transportation agencies conducted by the National Transportation Research Board, only 10 of 43 respondents indicated that they provide for incentive payments on construction contracts. The reluctance on the part of agencies to use such provisions is due to arguments that include<sup>19</sup>:

- Difficulty in budgeting an amount for bonus payments.
- Need for additional data to decide on an amount or rate.
- Value received may not be proportional to the additional cost.
- Increase in claims by contractors.
- Provision in contract for liquidated damages is sufficient incentive.



Additionally, agency officials are wary of the criticism that would likely result if a contractor were to collect a substantial bonus as a result of exceptional diligence, even though possible increased construction costs are avoided, early completion results in earlier use of the facility, and the opportunity to place bids and receive bonus payments are open to other contractors.

An example of special provisions for incentive payments and liquidated damages used by the Illinois Department of Transportation in contracts for rehabilitation projects is shown in Figure 2.5.<sup>20</sup> As illustrated in Figure 2.6, the provisions provide for a maximum incentive payment of \$5000 per day for a period of 50 days, then a month of no incentive payments or liquidated damages, and finally a liquidated damages rate of \$10,000 per day thereafter.

#### H. Consequences of Contract Time Determination.

In order to decrease the possibility of differences or disputes with the contractor, setting realistic contract time limits is a primary goal of state transportation agencies. Contractors, in the vast majority of cases, prepare their own estimates of time needed to complete a project based on the abilities of their own companies. If an agency is to set realistic contract durations, it must be aware of contractor capabilities.





CONTRACT #33482  
FAI Route 94  
Section  
1975-118-R&BR  
Cook County

SPECIAL PROVISION--INCENTIVE/LIQUIDATED DAMAGES

Because time is of the essence in completing the contract work Sections 108.10, 102.07(c), and 102.07(f) of the Department's Standard Specifications for Road and Bridge Construction are hereby deleted in their entirety and the following is substituted therefor:

FAILURE TO COMPLETE THE WORK ON TIME

NORTHBOUND LANES

Should the Contractor fail to complete all the work including cleanup on the northbound lanes as required by this contract, on or before October 31, 1979, the Contractor shall be liable to the Department for each calendar day after October 31, 1979, as liquidated damages and not as a penalty, in the amount of \$10,000. Such daily amount shall continue to accrue until such time as all work on the northbound lanes under this contract is completed. Provided, however, if this contract is part of a combination bid award, such daily amount shall continue to accrue regardless of completion of work on the northbound lanes under this contract until all work on contracts which are a part of the combination award has been completed.

INCENTIVE PAYMENT

NORTHBOUND LANES

Should the Contractor complete all the work on the northbound lanes including cleanup, as required by this contract; before September 30, 1979, the Contractor shall be entitled to \$5,000 as an individual incentive payment for each calendar day of completion prior to September 30, 1979. No individual incentive payment will be made should any work not be completed before September 30, 1979, regardless of any extension of time. Individual incentive payments shall in no event be paid for more than 50 calendar days. If this contract is part of a combination award, no individual incentive payment shall commence on this or any other contract which is a part of the combination until all work on contracts which are a part of the combination award has been completed.

Should all work on the northbound lanes be completed for all six sections of the Edens Expressway reconstruction as covered by this contract and by Department contracts numbered 33434, 33470, 33461, 33432, 33433, the Contractor shall be entitled to an additional \$5,000 as a cooperative incentive payment for each calendar day of completion prior to September 30, 1979. No cooperative incentive payment will be made solely because the Contractor has finished early and no cooperative incentive payments will begin to accrue until the date of completion of all work on the northbound lanes under this contract and the five contracts enumerated above. The Contractor and the Department recognize that the prosecution of work by other contractors may not be effectively under the control of the Contractor; however, it is also recognized and agree that the nature of the project is such that use of the highway cannot safely and efficiently begin until all sections are completed. No cooperative incentive payment will be made should any work not be completed before September 30, 1979, regardless of any extension of time. Cooperative incentive payments shall in no event be paid for more than 50 calendar days.

Figure 2.5 - Special provisions for incentive payments and liquidated damages (Illinois).





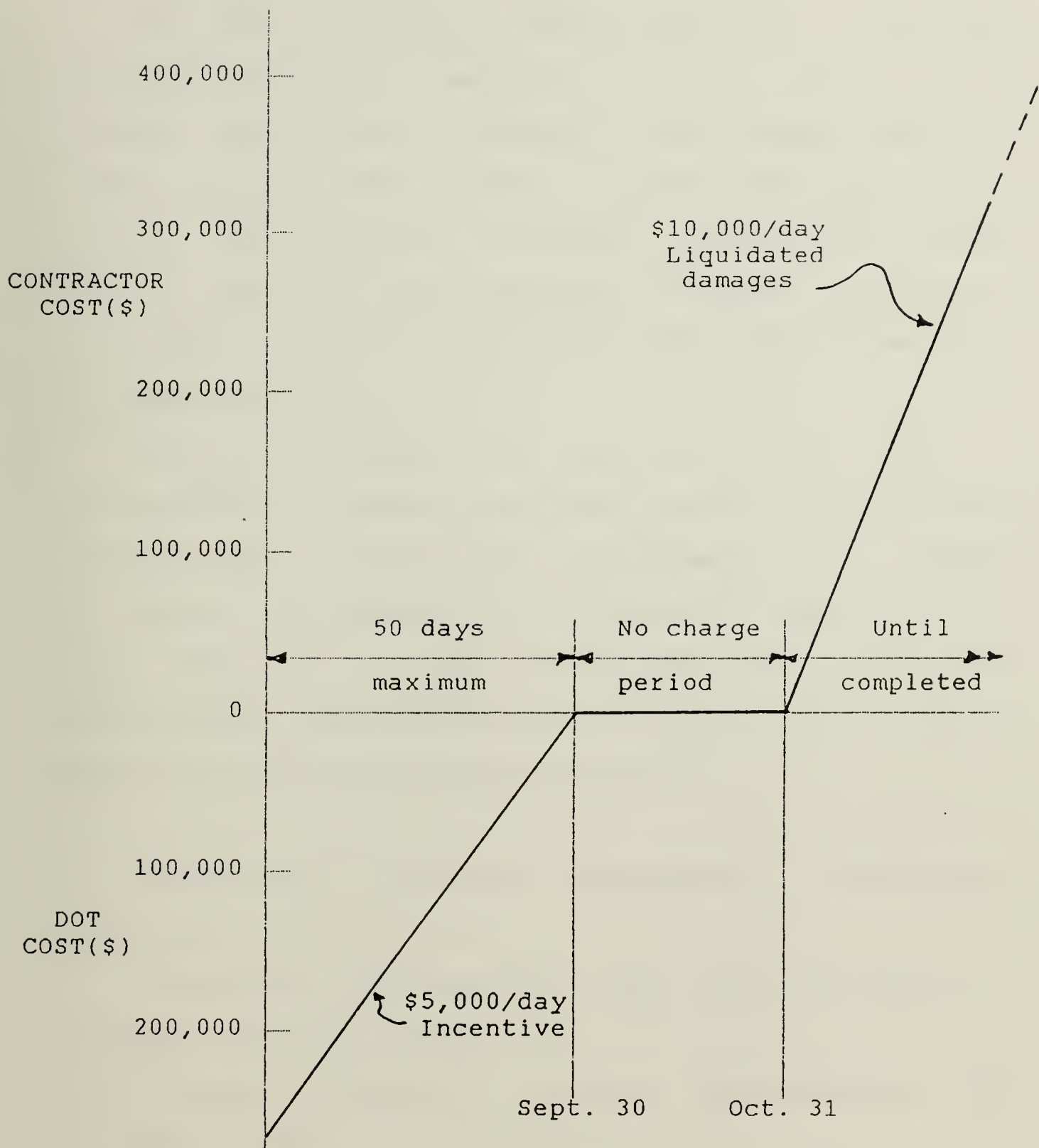


Figure 2.6 Computation of Incentive Payments and Liquidated Damages for a Specific Contract in Illinois [An additional \$5,000 per day incentive payment was available if all six contracts were completed early (see Figure 2.5).]



In the interest of being profitable, contractors generally strive to complete a project at the earliest possible date. Early completion of a project results in lower overhead costs, lower interest costs for borrowed dollars, less exposure to damage by the elements (repairs must be made at the contractor's expense), avoidance of increased costs of labor and materials, and freedom to bid on other work.<sup>21</sup>

Contractor delays are quite often the result of incompetence or financial problems, however, a construction contract that does not allow for adequate time to complete the work, or allows for too much time to complete the work also has an effect on contractor performance. Specifically, contracts that specify an excessive number of working days or a long time period may<sup>22</sup>:

- Discourage innovative management or construction techniques.

- Encourage contractors to bid more work than can be handled in a timely manner.

- Require increased agency administration and engineering costs.

- Encourage lower bid prices.

- Permit both high- and low-production contractors to bid on a project.

- Reduce the bonding capacity of contractors.



Contracts that specify too few working days or a short time period may:

- Encourage higher bids.
- Increase bond costs for contractors.
- Eliminate some qualified contractors.
- Encourage good management and thus high production.
- Cause the contractor to question each work-day charge (on working-day contracts).
- Lower administration and engineering costs.

Good planning and scheduling practices on the part of state agencies not only provide a predictable means for determining reasonable contract durations, but also a means by which to manage and control the progression of contract work. Job progress can be tracked, delays can be better anticipated, scheduling disputes can be more easily resolved, and agency resources such as manpower allocation for project inspection can be managed more effectively.

The 1986 edition of the Florida DOT Specifications, shown in Appendix B, provides an example of how many of the issues discussed above are covered in highway construction contracts.



### CHAPTER III

#### CONTRACT TIME DETERMINATION METHODS SURVEY

##### A. General.

In order to gather information on methods used to determine construction contract durations by state transportation agencies across the country, a survey was conducted which requested information on procedures followed. An example survey letter which was sent to the Arizona Department of Transportation is shown in Figure 3.1. This survey letter also requested information pertaining to the use of productivity rates used by state agencies. To facilitate replies, a questionnaire (see Figure 3.2) was enclosed for agencies to complete.

##### B. Survey Response.

Response to the survey was excellent. Of all the requests for information mailed out, nearly three-quarters of those receiving them responded.

Replies received varied from single-sentence answers to packages of considerable volume. As expected, methods of determining contract durations vary from state to state,







COLLEGE  
OF  
ENGINEERING

UNIVERSITY OF FLORIDA

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DEPARTMENT OF CIVIL ENGINEERING

September 4, 1987

RECEIVED  
ADOT

SEP 16 1987

Mr. Frank R. McCullagh  
Director  
Arizona Department of Transportation  
P. O. Box 13588  
Phoenix, AZ 85007

ARIZONA TRANSPORTATION  
Research Center

Dear Mr. McCullagh:

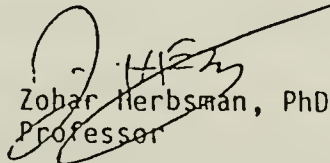
We are conducting a research study for the Florida Department of Transportation (FDOT) to evaluate and suggest improvements to their method of determining specified contract durations. The current method employed by FDOT for determining contract duration is based on productivity rates and total material quantities for specific activities.

As a part of our study we are contacting other state transportation authorities in order to learn what methods they are using.

We request your assistance in providing any information available concerning your procedure for establishing contract durations for new contracts. If you also use productivity rates in calculating contract durations, we would very much like to know what the rates are and what adjusting factors, if any, are used.

To assist in your reply, we have enclosed a questionnaire which we would appreciate you returning at your earliest convenience.

Sincerely,

  
Zohar Herbsman, PhD  
Professor

ZH/ck1

Enclosure

RECEIVED

SEP 30 1987

CONTRACTS & SPECIFICATIONS

RECEIVED

SEP 18 1987

CONST. SECTION

FLORIDA'S CENTER FOR ENGINEERING EDUCATION AND RESEARCH

EQUAL EMPLOYMENT OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER



Please Respond As Soon as Possible

REPLY TO:

Dr. Z. Herbsman  
University of Florida  
Department of Civil Engineering  
346 Weil Hall  
Gainesville, FL 32611

METHOD USED TO DETERMINE CONTRACT DURATION:

(Please describe your procedure)

Our current practice in determining contract duration is very much like that of most other agencies. Simple bar charts, or something approximating that, are generally prepared by our estimators based on their individual assessments of the amount of time necessary to perform major elements of work. This has been a reasonably reliable technique for all but the very largest and most complex jobs. The time required to do anything more involved than this is just not available. We are moving toward a computerized estimating system which may eventually allow a more sophisticated procedure with possibly greater accuracy. We do have available to us, at present, information developed by another office, which is intended to provide our district offices with manpower projections, however, it has not proven any better than the bar charts for accuracy.

PLEASE SEND US COPIES OF ANY DOCUMENTATION AVAILABLE.

Such as: Written procedures  
Work forms, calculation sheets  
Schedule of production rates used.

PLEASE GIVE THE NAME OF PERSON WHO MAY BE CONTACTED FOR ADDITIONAL INFORMATION:

Name: DAVID G. ELACK

Position: TRANSPORTATION ENGINEER - SUPERVISOR

State Highway Authority: ARIZONA DEPT. OF TRANSPORTATION

Mailing Address: 1651 W. JACKSON RM 121F

PHOENIX, ARIZONA 85007

Telephone No.: (602) 255-7221

Figure 3.2 Arizona DOT Questionnaire



however, this report has attempted to group together those methods that have enough correlation to be considered similar in procedure.

### C. Summary of Findings.

Study of responses received by state transportation agencies on methods used to determine contract durations reveal that there are generally four basis upon which contract durations are commonly calculated. These are:

- Construction season limits,
- Quantity or production rates,
- Work-flow techniques, and
- Estimated costs.

Other less common methods include time unit calculation and completion dates specified by the contractor at the time of the bid.

In their Synthesis of Highway Practice, Special Report Number 79, the Transportation Research Board tabulated results of an extensive survey they conducted in 1981 which gives a breakdown, by state, of procedures used in determining contract time, along with other information discussed earlier in this report such as liquidated damages and incentive payments. This information is shown in Figure 3.3. Chapter IV offers representative methods of



# CURRENT PRACTICES FOR DETERMINING CONTRACT TIME

| STATE          | Contract Time Determined by |                   |                | Have Bids Ever Been Based on Different Numbers of Days? | Techniques or Procedures Used to Determine Contract Time |                      |         |               | Liquidated Damages Range/Day (\$) | Bonus Range/Day (\$) |
|----------------|-----------------------------|-------------------|----------------|---|--|----------------------|---------|---------------|-----------------------------------|----------------------|
|                | Working Days (%)            | Calendar Days (%) | Fixed Date (%) |   | Work Season (%)  | Production Rates (%) | CPM (%) | Cost Est. (%) |                                   |                      |
| ALABAMA        | 97                          | 1                 | 2              | No  | X  |                      |         | X             | 45 - 980                          |                      |
| ALASKA         |                             | X                 | X              | No  | X  |                      |         |               | 50 - 500                          |                      |
| ARIZONA        | X                           |                   |                | No  |  | X                    |         |               | 42 - 420                          |                      |
| ARKANSAS       | X                           |                   |                | No  |  | X                    |         |               | 42 - 420                          |                      |
| CALIFORNIA     | X                           |                   |                | No  | 20   | 60                   | 20      |               | 50 - 1500                         |                      |
| DELAWARE       | X                           | X                 | X              | No  | 10   | 30                   |         | 60            | 30 - 420                          |                      |
| DIST OF COL.   |                             |                   |                | Yes   |  |                      |         | X             | 30 - 150                          |                      |
| FLORIDA        |                             | X                 |                | No  |  | X                    |         |               | (1) - 300                         |                      |
| GEORGIA        | 60                          | 5                 | 35             | No  | 30   | 70                   |         |               | 30 - 420                          |                      |
| HAWAII         | X                           |                   |                | No  | 10   | 30                   | 30      | 30            | 42 - 420                          |                      |
| IDAH0          | 95                          | 1                 | 4              | Yes   | X  |                      |         |               | 75 - 1300                         |                      |
| ILLINOIS       | 99.5                        |                   | 0.5            | No  |  | X                    |         |               | 30 - 5600                         | 1500 - 10 000        |
| INDIANA        | 5.2                         | 1                 | 48             | No  | X  | X                    |         |               | 30 - 1000                         | (2) 50 - 1000 day    |
| IOWA           | X                           |                   |                | Yes (3)   |  | X                    |         |               | 42 - 200                          |                      |
| KANSAS         | X                           |                   |                | No  |  | X                    |         |               | 75 - 1500                         | (11) 750 -           |
| KENTUCKY       | 35                          |                   | 65             | No  | 65   | 35                   |         |               | 60 - 600                          |                      |
| LOUISIANA      | 80                          | 20                | --             | No  |  | X                    |         | X             | 42 - 420                          |                      |
| MAINE          | 80                          |                   | 20             | No  |  | X                    |         |               | 30 - 420                          |                      |
| MARYLAND       | 75                          | 25                |                | No  | X  | X                    |         | X             | (4)                               |                      |
| MASSACHUSETTS  |                             |                   | X              | No  | X  |                      |         | X             | 30 - 500                          |                      |
| MICHIGAN       | 70                          |                   | 30             | No  | 20   |                      | 80      |               | 20 - 1000                         | (5)                  |
| MINNESOTA      | 90                          | 10                | 10             | No  |  |                      |         |               | 150 - 900                         | (6) 1000 - 3500      |
| MISSISSIPPI    |                             |                   | X              |   |  | X                    |         |               | 0 - 560                           |                      |
| MISSOURI       | 95                          |                   | X              | No  | 50   | 50                   |         |               | 50 - 1500                         |                      |
| MONTANA        | X                           |                   | X              | No  | X  | X                    |         |               | 28 - 420                          |                      |
| NEBRASKA       | 98                          | 2                 |                | No  |  | X                    |         |               | 42 - 420                          | (7)                  |
| NEVADA         | X                           |                   |                | No  |  |                      | X       |               | 300 - 1000                        |                      |
| NEW HAMPSHIRE  | 2                           |                   | 98             | No  | X  |                      |         |               | 30 - 300                          | (8) 100 - 500        |
| NEW YORK       |                             |                   | X              | No  | X  |                      |         |               | 50 - 1000                         |                      |
| NORTH DAKOTA   | 20                          |                   | 80             | No  | 75   | 15                   |         | 10            | 50 - 700                          | (9) - 500            |
| OHIO           | X                           |                   |                | No  | X  | X                    |         |               | 30 - 600                          |                      |
| OKLAHOMA       | 75                          | 15                | 10             | No  | 25   | 75                   |         |               | 30 - 1000                         |                      |
| OREGON (10)    | 1                           | 50                | 20             | No  | X  | X                    |         | X             | 40 - 840                          |                      |
| PENNSYLVANIA   |                             | X                 | (12)           |   | X  |                      | (13)    |               | 300                               |                      |
| RHODE ISLAND   |                             |                   |                | Yes   | X  | X                    |         |               | 30 - 300                          |                      |
| SOUTH CAROLINA | X                           |                   | X              | No  | X  |                      |         | X             | 20 - 420                          |                      |
| SOUTH DAKOTA   |                             |                   | X              | No  | X  |                      |         |               | 50 - 600                          |                      |
| TENNESSEE      | 90                          |                   | 10             | No  | X  | X                    |         | X             | 30 - 420                          |                      |
| UTAH           | X                           | X                 | X              | No  | X  |                      |         | X             | 42 - 420                          |                      |
| VERMONT        |                             |                   | X              | No  | X  |                      |         |               | 42 - 420                          |                      |
| VIRGINIA       |                             | X                 | X              | No  | X  | X                    |         |               | 50 - 500                          |                      |
| WASHINGTON     | X                           |                   | 0.5            | No  | X  |                      |         |               | 42 - 2000                         | 0 - 2000             |
| WISCONSIN      | 30                          | 40                | 30             | No  |  | 90                   | 10      |               | 50 - 595                          |                      |
| WYOMING        |                             |                   | X              | No  | X  | X                    | X       |               | 50 - 600                          |                      |

NOTES: (1) 1/4% of contract amount per day. (2) Used on less than 1% of contracts with "not to exceed limit." (3) Only on selected projects with normal versus round-the-clock day. (4) Based on engineering, administration, and other costs of time overrun. (5) Used in special cases. (6) Bonus set by special provision. (7) Same as penalty, but rarely used. (8) Only for special projects. (9) Recent use on selected projects with \$400-500 range. (10) Calendar work days - 29%. (11) One project only. (12) Only under special circumstances. (13) Bar

Figure 3.3 Current Practices for Determining Contract Time







determining contract durations based on survey material received from various states.

### Construction Season Limits

Highway construction, particularly surfacing and paving projects, is severely dependent upon the weather. When letting contracts of this nature, state agencies must consider the limits of the construction season where the work is to be performed. Often, contract durations are based on the time that weather is expected to permit work to continue during the construction season.

When based on construction season limits, contract times are only effectively predictable when projects are awarded sufficiently early in the construction season to allow completion, a large number of jobs are not given to a single contractor, materials are readily available, and the contractor is held responsible for the expense of maintaining the project over the winter or paying liquidated damages.<sup>23</sup>

Meteorological data has been collected by many of the state agencies and combined with experience and historical construction data in the attempt to determine just how many working days there are in a year for areas under agency cognizance for various types of construction. Working-day charts and tables for the state of Georgia are shown in Figures 3.4 and 3.5, and for the state of Indiana in Figures



# GEORGIA STATE HIGHWAY DEPARTMENT WEATHER ZONE MAP

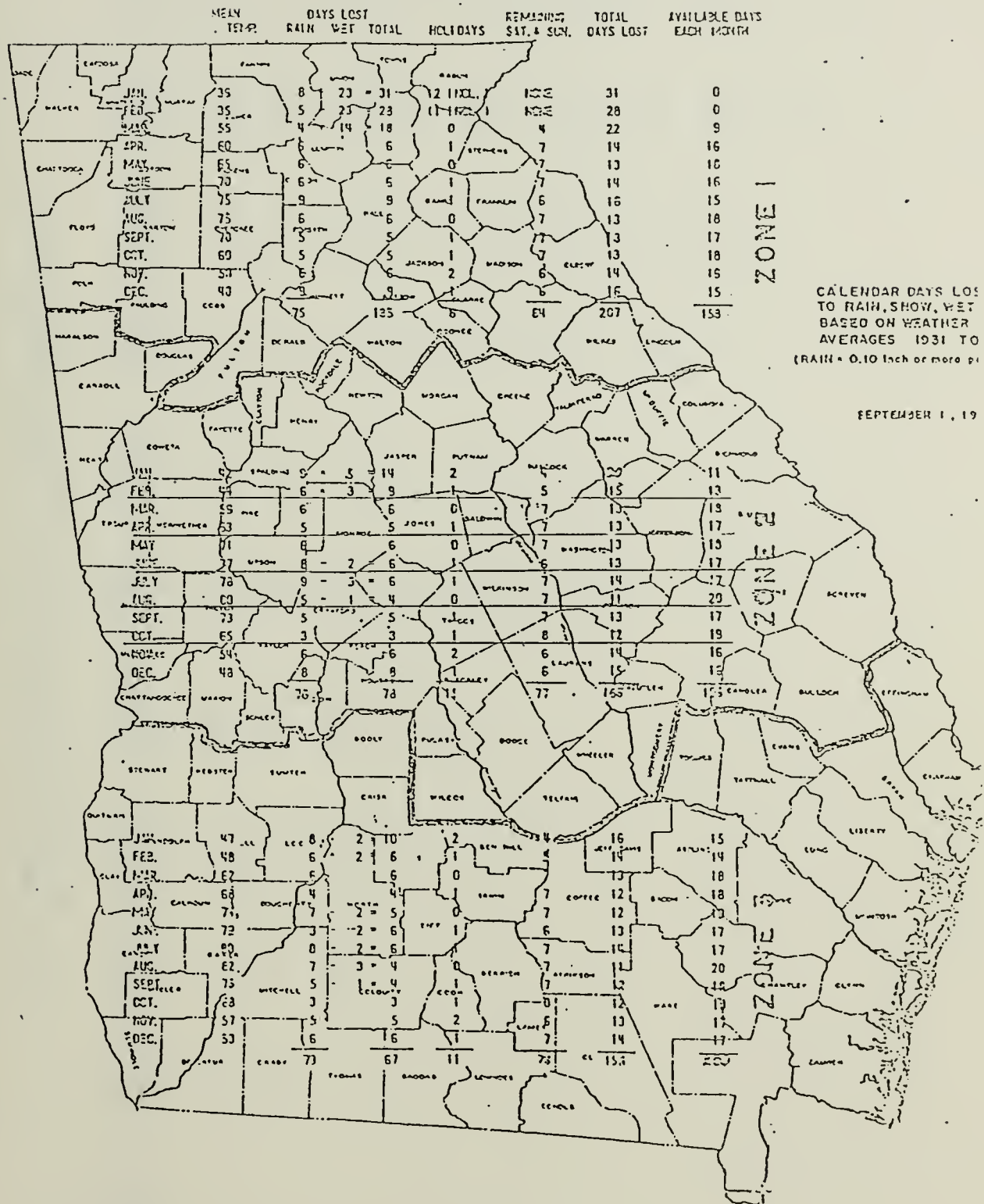


Figure 3.4 Available Work Day Zone Map (Georgia)



AVERAGE AVAILABLE WORKING DAYS FOR BRIDGE CONSTRUCTION  
IN THE ATLANTA AREA AS OF OCTOBER 1967

| JAN. | FEB. | MAR. | APR. | MAY | JUN. | JUL. | AUG. | SEP. | OCT. | NOV. | DEC. |
|------|------|------|------|-----|------|------|------|------|------|------|------|
| 8.   | 16   | 31   | 49   | 69  | 89   | 108  | 123  | 147  | 165  | 182  | 201  |
|      | 8    | 23   | 41   | 61  | 81   | 100  | 120  | 139  | 157  | 174  | 193  |
|      |      | 15   | 33   | 53  | 73   | 92   | 112  | 131  | 149  | 166  | 185  |
|      |      |      | 18   | 38  | 58   | 77   | 97   | 116  | 134  | 151  | 170  |
|      |      |      |      | 20  | 40   | 59   | 79   | 98   | 116  | 133  | 152  |
|      |      |      |      |     | 20   | 39   | 59   | 78   | 96   | 113  | 132  |
|      |      |      |      |     |      | 19   | 39   | 58   | 76   | 93   | 112  |
|      |      |      |      |     |      |      | 20   | 39   | 57   | 74   | 93   |
|      |      |      |      |     |      |      |      | 19   | 37   | 54   | 73   |
|      |      |      |      |     |      |      |      |      | 18   | 35   | 54   |
|      |      |      |      |     |      |      |      |      |      | 17   | 36   |
|      |      |      |      |     |      |      |      |      |      |      | 19   |

Figure 3.5 Working Day Chart for Bridge Construction  
(Atlanta, Georgia)



3.6, 3.7, and 3.8. These figures are fairly representative of the manner in which working-days are calculated and tabulated among the states that take construction seasons into consideration when determining contract durations. As demonstrated in the charts formulated by the Indiana DOT, working-day calculations are sometimes established for different types of work such as bridge construction, light grading and urban construction, or medium and heavy grading work.

Calculated values of available work-days are most often used in combination with the other methods of determining contract durations; rarely are they used alone.

#### Quantity or Production Rates

Based on experience and past data from completed projects, many states compute daily production rates for work items that effect project time. Figures 3.9, 3.10, and 3.11 illustrate the tabulation of these values. The advantage of this system is that it breaks down projects into critical work activities, just as contractors would normally do when they determine the time needed to complete a job.

Some states have gone a step further and developed productivity curves based on the quantity of work involved for different work items in a project. These allow agency





APRIL 1971

| BRIDGE<br>DISTRIBUTION OF WORKING DAYS<br>BY MONTHS, THRU 135 W.D. YEAR<br>CUMULATIVE TOTALS PER MONTH. |      |     |      |     |      |     |      |     |     |     |      |     |      |
|---|------|-----|------|-----|------|-----|------|-----|-----|-----|------|-----|------|
|   | JAN. |     | FEB. |     | MAR. |     | APR. |     | MAY |     | JUN. |     | JUL. |
|   | JAN. |     | FEB. |     | MAR. |     | APR. |     | MAY |     | JUN. |     | JUL. |
|   | FEB. |     |      |     |      |     |      |     |     |     |      |     |      |
|   | MAR. |     |      |     |      |     |      |     |     |     |      |     |      |
| 14  | APR. | 14  | 14   | 14  | 14   | 14  | 14   | 14  | 14  | 14  | 14   | 14  | 14   |
| 16  | MAY  | 30  | 30   | 30  | 30   | 30  | 30   | 30  | 30  | 30  | 30   | 30  | 30   |
| 18  | JUN  | 48  | 48   | 48  | 48   | 48  | 48   | 48  | 48  | 48  | 48   | 48  | 48   |
| 19  | JUL  | 67  | 67   | 67  | 67   | 67  | 67   | 67  | 67  | 67  | 67   | 67  | 67   |
| 18  | AUG  | 85  | 85   | 85  | 85   | 85  | 85   | 85  | 85  | 85  | 85   | 85  | 85   |
| 18  | SEP  | 103 | 103  | 103 | 103  | 103 | 103  | 103 | 103 | 103 | 103  | 103 | 103  |
| 17  | OCT  | 120 | 120  | 120 | 120  | 120 | 120  | 120 | 120 | 120 | 120  | 120 | 120  |
| 15  | NOV  | 135 | 135  | 135 | 135  | 135 | 135  | 135 | 135 | 135 | 135  | 135 | 135  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     | 0    |
| 0   | JAN  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | FEB  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 14  | APR  | 149 | 149  | 149 | 149  | 149 | 149  | 149 | 149 | 149 | 149  | 149 | 149  |
| 16  | MAY  | 165 | 165  | 165 | 165  | 165 | 165  | 165 | 165 | 165 | 165  | 165 | 165  |
| 18  | JUN  | 183 | 183  | 183 | 183  | 183 | 183  | 183 | 183 | 183 | 183  | 183 | 183  |
| 19  | JUL  | 202 | 202  | 202 | 202  | 202 | 202  | 202 | 202 | 202 | 202  | 202 | 202  |
| 18  | AUG  | 220 | 220  | 220 | 220  | 220 | 220  | 220 | 220 | 220 | 220  | 220 | 220  |
| 18  | SEP  | 238 | 238  | 238 | 238  | 238 | 238  | 238 | 238 | 238 | 238  | 238 | 238  |
| 17  | OCT  | 255 | 255  | 255 | 255  | 255 | 255  | 255 | 255 | 255 | 255  | 255 | 255  |
| 15  | NOV  | 270 | 270  | 270 | 270  | 270 | 270  | 270 | 270 | 270 | 270  | 270 | 270  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | JAN  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | FEB  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 14  | APR  | 284 | 284  | 284 | 284  | 284 | 284  | 284 | 284 | 284 | 284  | 284 | 284  |
| 16  | MAY  | 300 | 300  | 300 | 300  | 300 | 300  | 300 | 300 | 300 | 300  | 300 | 300  |
| 18  | JUN  | 318 | 318  | 318 | 318  | 318 | 318  | 318 | 318 | 318 | 318  | 318 | 318  |
| 19  | JUL  | 337 | 337  | 337 | 337  | 337 | 337  | 337 | 337 | 337 | 337  | 337 | 337  |
| 18  | AUG  | 355 | 355  | 355 | 355  | 355 | 355  | 355 | 355 | 355 | 355  | 355 | 355  |
| 18  | SEP  | 373 | 373  | 373 | 373  | 373 | 373  | 373 | 373 | 373 | 373  | 373 | 373  |
| 17  | OCT  | 390 | 390  | 390 | 390  | 390 | 390  | 390 | 390 | 390 | 390  | 390 | 390  |
| 15  | NOV  | 405 | 405  | 405 | 405  | 405 | 405  | 405 | 405 | 405 | 405  | 405 | 405  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | JAN  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | FEB  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 14  | APR  | 419 | 419  | 419 | 419  | 419 | 419  | 419 | 419 | 419 | 419  | 419 | 419  |
| 16  | MAY  | 435 | 435  | 435 | 435  | 435 | 435  | 435 | 435 | 435 | 435  | 435 | 435  |
| 18  | JUN  | 453 | 453  | 453 | 453  | 453 | 453  | 453 | 453 | 453 | 453  | 453 | 453  |
| 19  | JUL  | 472 | 472  | 472 | 472  | 472 | 472  | 472 | 472 | 472 | 472  | 472 | 472  |
| 18  | AUG  | 490 | 490  | 490 | 490  | 490 | 490  | 490 | 490 | 490 | 490  | 490 | 490  |
| 18  | SEP  | 508 | 508  | 508 | 508  | 508 | 508  | 508 | 508 | 508 | 508  | 508 | 508  |
| 17  | OCT  | 525 | 525  | 525 | 525  | 525 | 525  | 525 | 525 | 525 | 525  | 525 | 525  |
| 15  | NOV  | 540 | 540  | 540 | 540  | 540 | 540  | 540 | 540 | 540 | 540  | 540 | 540  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     |      |

Figure 3.6 Working Day Chart for Bridge Construction (Indiana)



APRIL 1971

| DISTRIBUTION OF WORKING DAYS<br>BY MONTHS, THRU 110 W.D. YEAR<br>CUMULATIVE TOTALS PER MONTH. |      |     |      |     |      |     |      |     |     |     |      |     |      |
|---|------|-----|------|-----|------|-----|------|-----|-----|-----|------|-----|------|
|   | JAN. |     | FEB. |     | MAR. |     | APR. |     | MAY |     | JUN. |     | JUL. |
| 0   | JAN. |     | FEB. |     | MAR. |     | APR. |     | MAY |     | JUN. |     | JUL. |
| 0   | FEB. |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 4   | APR  | 4   | 4    | 4   | 4    |     |      |     |     |     |      |     |      |
| 13  | MAY  | 17  | 17   | 17  | 17   | 13  |      |     |     |     |      |     |      |
| 17  | JUN  | 34  | 34   | 34  | 34   | 30  | 17   |     |     |     |      |     |      |
| 18  | JUL  | 52  | 52   | 52  | 52   | 48  | 35   | 18  |     |     |      |     |      |
| 18  | AUG  | 70  | 70   | 70  | 70   | 66  | 53   | 36  | 18  |     |      |     |      |
| 18  | SEP  | 88  | 88   | 88  | 88   | 84  | 71   | 54  | 36  | 18  |      |     |      |
| 17  | OCT  | 105 | 105  | 105 | 105  | 101 | 88   | 71  | 53  | 35  | 17   |     |      |
| 5   | NOV  | 110 | 110  | 110 | 110  | 106 | 93   | 76  | 58  | 40  | 22   | 5   |      |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     | 0    |
| 0   | JAN  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | FEB  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 4   | APR  | 114 | 114  | 114 | 114  | 110 | 97   | 80  | 62  | 44  | 26   | 9   | 4    |
| 13  | MAY  | 127 | 127  | 127 | 127  | 123 | 110  | 93  | 75  | 57  | 39   | 22  | 17   |
| 17  | JUN  | 144 | 144  | 144 | 144  | 140 | 127  | 110 | 92  | 74  | 56   | 39  | 34   |
| 18  | JUL  | 162 | 162  | 162 | 162  | 158 | 145  | 128 | 110 | 92  | 74   | 57  | 52   |
| 18  | AUG  | 180 | 180  | 180 | 180  | 176 | 163  | 146 | 128 | 110 | 92   | 75  | 70   |
| 18  | SEP  | 198 | 198  | 198 | 198  | 194 | 181  | 164 | 146 | 128 | 110  | 93  | 88   |
| 17  | OCT  | 215 | 215  | 215 | 215  | 211 | 198  | 181 | 163 | 145 | 127  | 110 | 105  |
| 5   | NOV  | 220 | 220  | 220 | 220  | 216 | 203  | 186 | 168 | 150 | 132  | 115 | 110  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | JAN  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | FEB  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 4   | APR  | 224 | 224  | 224 | 224  | 220 | 207  | 190 | 172 | 154 | 136  | 119 | 114  |
| 13  | MAY  | 237 | 237  | 237 | 237  | 233 | 220  | 203 | 185 | 167 | 149  | 132 | 127  |
| 17  | JUN  | 254 | 254  | 254 | 254  | 250 | 237  | 220 | 202 | 184 | 166  | 149 | 144  |
| 18  | JUL  | 272 | 272  | 272 | 272  | 268 | 255  | 238 | 220 | 202 | 184  | 167 | 162  |
| 18  | AUG  | 290 | 290  | 290 | 290  | 286 | 273  | 256 | 238 | 220 | 202  | 185 | 180  |
| 18  | SEP  | 308 | 308  | 308 | 308  | 304 | 291  | 274 | 256 | 238 | 220  | 203 | 198  |
| 17  | OCT  | 325 | 325  | 325 | 325  | 321 | 308  | 291 | 273 | 255 | 237  | 220 | 215  |
| 5   | NOV  | 330 | 330  | 330 | 330  | 326 | 313  | 296 | 278 | 260 | 242  | 225 | 220  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | JAN  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | FEB  |     |      |     |      |     |      |     |     |     |      |     |      |
| 0   | MAR  |     |      |     |      |     |      |     |     |     |      |     |      |
| 4   | APR  | 334 | 334  | 334 | 334  | 330 | 317  | 300 | 282 | 264 | 246  | 229 | 224  |
| 13  | MAY  | 347 | 347  | 347 | 347  | 343 | 330  | 313 | 295 | 277 | 259  | 242 | 237  |
| 17  | JUN  | 364 | 364  | 364 | 364  | 360 | 347  | 330 | 312 | 294 | 276  | 259 | 254  |
| 18  | JUL  | 382 | 382  | 382 | 382  | 378 | 365  | 348 | 330 | 312 | 294  | 277 | 272  |
| 18  | AUG  | 400 | 400  | 400 | 400  | 396 | 383  | 366 | 348 | 330 | 312  | 295 | 290  |
| 18  | SEP  | 418 | 418  | 418 | 418  | 414 | 401  | 384 | 366 | 348 | 330  | 313 | 308  |
| 17  | OCT  | 435 | 435  | 435 | 435  | 431 | 418  | 401 | 383 | 365 | 347  | 330 | 325  |
| 5   | NOV  | 440 | 440  | 440 | 440  | 436 | 423  | 406 | 388 | 370 | 352  | 335 | 330  |
| 0   | DEC  |     |      |     |      |     |      |     |     |     |      |     |      |

Figure 3.7 Working Day Chart for Light Grading and Urban Construction (Indiana)



APRIL 1971

| DISTRIBUTION OF WORKING DAYS<br>BY MONTHS, THRU 100 W.D. YEAR<br>CUMULATIVE TOTALS PER MONTH. |      |      |      |      |     |      |      |      |       |      |      |      |  |
|---|------|------|------|------|-----|------|------|------|-------|------|------|------|--|
|   | JAN. | FEB. | MAR. | APR. | MAY | JUN. | JUL. | AUG. | SEPT. | OCT. | NOV. | DEC. |  |
| 0 JAN.  |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 FEB.  |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 MAR.  |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 4 APR.  | 4    | 4    | 4    | 4    |     |      |      |      |       |      |      |      |  |
| 13 MAY  | 17   | 17   | 17   | 17   | 13  |      |      |      |       |      |      |      |  |
| 15 JUN  | 32   | 32   | 32   | 32   | 28  | 15   |      |      |       |      |      |      |  |
| 16 JUL  | 48   | 48   | 48   | 48   | 44  | 31   | 16   |      |       |      |      |      |  |
| 17 AUG  | 65   | 65   | 65   | 65   | 61  | 48   | 33   | 17   |       |      |      |      |  |
| 15 SEP  | 80   | 80   | 80   | 80   | 76  | 63   | 48   | 32   | 15    |      |      |      |  |
| 15 OCT  | 95   | 95   | 95   | 95   | 91  | 78   | 63   | 47   | 30    | 15   |      |      |  |
| 5 NOV   | 100  | 100  | 100  | 100  | 96  | 83   | 68   | 52   | 35    | 20   | 5    |      |  |
| 0 DEC   |      |      |      |      |     |      |      |      |       |      |      | 0    |  |
| 0 JAN   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 FEB   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 MAR   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 4 APR   | 104  | 104  | 104  | 104  | 100 | 87   | 72   | 56   | 39    | 24   | 9    | 4    |  |
| 13 MAY  | 117  | 117  | 117  | 117  | 113 | 100  | 85   | 69   | 52    | 37   | 22   | 17   |  |
| 15 JUN  | 132  | 132  | 132  | 132  | 128 | 115  | 100  | 84   | 67    | 52   | 37   | 32   |  |
| 16 JUL  | 148  | 148  | 148  | 148  | 144 | 131  | 116  | 100  | 83    | 68   | 53   | 48   |  |
| 17 AUG  | 165  | 165  | 165  | 165  | 161 | 148  | 133  | 117  | 100   | 85   | 70   | 65   |  |
| 15 SEP  | 180  | 180  | 180  | 180  | 176 | 163  | 148  | 132  | 115   | 100  | 85   | 80   |  |
| 15 OCT  | 195  | 195  | 195  | 195  | 191 | 178  | 163  | 147  | 130   | 115  | 100  | 95   |  |
| 5 NOV   | 200  | 200  | 200  | 200  | 196 | 183  | 168  | 152  | 135   | 120  | 105  | 100  |  |
| 0 DEC   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 JAN   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 FEB   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 MAR   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 4 APR   | 204  | 204  | 204  | 204  | 200 | 187  | 172  | 156  | 139   | 124  | 109  | 104  |  |
| 13 MAY  | 217  | 217  | 217  | 217  | 213 | 200  | 185  | 169  | 152   | 137  | 122  | 117  |  |
| 15 JUN  | 232  | 232  | 232  | 232  | 228 | 215  | 200  | 184  | 167   | 152  | 137  | 132  |  |
| 16 JUL  | 248  | 248  | 248  | 248  | 244 | 231  | 216  | 200  | 183   | 168  | 153  | 148  |  |
| 17 AUG  | 265  | 265  | 265  | 265  | 261 | 248  | 233  | 217  | 200   | 185  | 170  | 165  |  |
| 15 SEP  | 280  | 280  | 280  | 280  | 276 | 263  | 248  | 232  | 215   | 200  | 185  | 180  |  |
| 15 OCT  | 295  | 295  | 295  | 295  | 291 | 278  | 263  | 247  | 230   | 215  | 200  | 195  |  |
| 5 NOV   | 300  | 300  | 300  | 300  | 296 | 283  | 268  | 252  | 235   | 220  | 205  | 200  |  |
| 0 DEC   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 JAN   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 FEB   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 0 MAR   |      |      |      |      |     |      |      |      |       |      |      |      |  |
| 4 APR   | 304  | 304  | 304  | 304  | 300 | 287  | 272  | 256  | 239   | 224  | 209  | 204  |  |
| 13 MAY  | 317  | 317  | 317  | 317  | 313 | 300  | 285  | 269  | 252   | 237  | 222  | 217  |  |
| 15 JUN  | 332  | 332  | 332  | 332  | 328 | 315  | 300  | 284  | 267   | 252  | 237  | 232  |  |
| 16 JUL  | 348  | 348  | 348  | 348  | 344 | 331  | 316  | 300  | 283   | 268  | 253  | 248  |  |
| 17 AUG  | 365  | 365  | 365  | 365  | 361 | 348  | 333  | 317  | 300   | 285  | 270  | 265  |  |
| 15 SEP  | 380  | 380  | 380  | 380  | 376 | 363  | 348  | 332  | 315   | 300  | 285  | 280  |  |
| 15 OCT  | 395  | 395  | 395  | 395  | 391 | 378  | 363  | 347  | 330   | 315  | 300  | 295  |  |
| 5 NOV   | 400  | 400  | 400  | 400  | 396 | 383  | 368  | 352  | 335   | 320  | 305  | 300  |  |
| 0 DEC   |      |      |      |      |     |      |      |      |       |      |      |      |  |

Figure 3.8 Working Day Chart for Medium and Heavy Grading  
(Indiana)





# FLORIDA DEPARTMENT OF TRANSPORTATION

## SPECIFICATIONS

### Criteria Used For Estimating Working Days

| <u>Work to be Considered</u>   | <u>Number of Working Days</u>  |
|--|--|
| 1. Clearing and Grubbing. 000023 Ac./SF  | 1 to 10 Acres per day,<br>depending upon nature; NOT<br>to exceed 20 (Grading time<br>will govern after 20 days) |
| 2. Excavation (Regular, Lat. Ditch,<br>Subsoil; Convert grading roadway<br>to Cu. Yds. for this purpose).<br>Shldr. grading (Resurfacing) at<br>1 mi/day | (See chart for No. Days)   |
| 3. Stabilized Roadbed  | 5,000 Sq. Yds. per day<br>(Not to exceed 10 days)  |
| 4. Bases (Sand-Clay; Limerock;<br>Limerock Stabilized,<br>Shell Stabilized; and<br>Soil Cement Base)   | (See chart for No. Days)   |
| 5. Surface Treatment   | 200 Cu. Yds. per day   |
| 6. Cement Concrete   | 5,000 Sq. Yds. per day   |
| 7. Milling Existing Pavement   | 4,000 Sq. Yds. per day<br>(Max 20 days)  |
| 8. Plant mixed surfaces<br>(in tons- for conversion see * below)   | (See chart for No. Days)   |
| 9. Storm Sewers (on Munic. Const.;<br>includes pipe, inlets, manholes, etc.)   | 100 to 400 linear ft. per day  |
| 10. Curb and Gutter, Valley Gutter, etc.   | 300 to 700 linear ft. per day  |
| 11. Sidewalk   | 300 Sq. Yds. per day   |
| 12. Sprigging/Grassing<br>2420 S   | 15,000 Sq. Yds. per day<br>(Not to exceed 15 days)<br>(225,000)  |

Figure 3.9 Standard Productivity Rates (Florida)





TIME LIMIT INFORMATION  
CONTRACTS AND SPECIFICATIONS SECTION  
(Select Controlling Items)

| <u>SECTION</u> | <u>ITEM</u>  | <u>CTR. TIME</u>  |
|----------------|--|---|
| 201            | Clearing and Grubbing                                      | 1.5 Acres/Day   |
| 202            | Removal of Timber Bridge                                   | 2 Spans/Day   |
| 202            | Removal of P. C. C. Pavement                               | 500 Sq.Yd./Day  |
| 202            | Removal of Conc. Box Culverts                              | 1/Day   |
| 202            | Removal of Asph. Concrete Surf.                            | 1 Mile/Day  |
| 203            | Excavation or Embankment<br>(Figure highest quantity only) | 3,000 Cu.Yds./Day (Country)<br>1,000 Cu.Yds./Day (City) |
| 203            | Mucking Ditches (consider section)                         | 1,000 Ft./-0.5 Mile/Day                                 |
| 203            | Mucking (Very large quantity)                              | 3,500 Cu.Yds./Day                                       |
| 203            | Shaping Roadbed  | 1 Mile/Day  |
| 203            | Shaping Roadway, Ditches & Slopes                          | 0.5 Mile/Day  |
| 203            | Shell (Spot Dumped)  | 500 Cu.Yds./Day   |
| 301            | Base Course (Non-Stabilized)                               | 1,500 Cu.Yds./Day                                       |
| 301            | Base Course (Class I)                                      | 1,000 Cu.Yds./Day                                       |
| 302            | Scarifying and Compacting Roadhead                         | 1 Mile/Day  |
| 303            | In-Place Cement Stabilized Base Course                     | 6,000 Sq.Yds./Day                                       |
| 304            | Lime Treatment (24 Ft. Width)<br>(20 Ft. Width)            | 6,000 Sq.Yds./Day<br>5,000 Sq.Yds./Day                  |
| 305            | Subbase Treatment  | 8,000 Sq.Yds. or 1 Mi./Day                              |

Figure 3.10 Standard Productivity Rates (Louisiana)



# CRITICAL PATH

APRIL 1984

## CONSTRUCTION TIME ESTIMATES

|      |  |                      |                            |
|------|--|----------------------|----------------------------|
| I.   | AWARD CONTRACT   | USE "WW" CODE        | 28 DAYS @ 7 DAY WEEK       |
| II.  | MOVE IN TIME   | USE "WW" CODE        | 10 DAYS @ 7 DAY WEEK       |
| III. | DRAINAGE   |                      |                            |
|      | A. CROSS CULVERTS (GENERALLY INCLUDED IN G&DS)         |                      |                            |
|      | 1. RURAL HIGHWAYS                                      |                      | 120 LFT./DAY               |
|      | 2. EXPRESSWAYS   |                      | 150 LFT./DAY               |
|      | 3. LARGE HEADWALLS                                     |                      | 5 DAYS/UNIT                |
|      | 4. SLAB OR BOX CULVERTS                                |                      | 5 DAYS/POUR                |
|      | 5. PLOWED IN EDGE DRAIN<br>(PRODUCTION TYPE PROJECT)   |                      | 150 STAS/DAY               |
|      | 6. OPEN-GRADED UNDERDRAIN<br>(PRODUCTION TYPE PROJECT) |                      | 40 STAS/DAY                |
|      | B. SEWERS  |                      |                            |
|      | 1. 0'-14' (UP TO 60")                                  |                      | 120 LFT./DAY               |
|      | 2. 0'-14' (OVER 60")                                   |                      | 80 LFT./DAY                |
|      | 3. 14'-OVER (UP TO 60")                                |                      | 80 LFT./DAY                |
|      | 4. 14'-OVER (OVER 60")                                 |                      | 60 LFT./DAY                |
|      | 5. JACKED-IN-PLACE<br>INCLUD. EXC. PIT AND SETUP       |                      | 40 LFT./DAY<br>MIN. 5 DAYS |
|      | 6. TUNNELS   |                      |                            |
|      | a. Hand Mining   |                      | 24 LFT./DAY                |
|      | b. Machine Mining                                      |                      | 60 LFT./DAY                |
|      | INCLUD. EXC. PIT AND SETUP                             |                      | MIN. 5 DAYS                |
|      | C. MANHOLES  |                      | 3 UNITS/DAY                |
|      | D. CATCHBASIN  |                      | 4 UNITS/DAY                |
| IV.  | UTILITIES  |                      |                            |
|      | A. WATER MAIN ( TO 16")                                |                      | 300 LFT./DAY               |
|      | FLUSHING, TESTING & CHLORINATION                       |                      | 4 DAYS                     |
|      | B. WATER MAIN ( 20" TO 42")                            |                      | 80 LFT./DAY                |
|      | FLUSHING, TESTING & CHLORINATION                       |                      | 5 DAYS                     |
|      | C. ORDER AND DELIVER 24" HP WATERMAIN                  | 50 DAYS @ 5 DAY WEEK |                            |
|      | D. GAS LINES   |                      | 300 LFT./DAY               |
| V.   | EARTHWORK AND GRADING                                  | DET.EXP.             | RURAL                      |
|      | A. EMB. CIP  | 2000                 | 7000 CYDS/DAY              |
|      | B. EXC. AND/OR EMB. (FREEWAY)                          | 2000                 | 12000 CYDS/DAY             |
|      | C. EXC. AND/OR EMB. (RECONST.)                         | 1000                 | 5000 CYDS/DAY              |
|      | D. EMB. (LIGHT WEIGHT FILL)                            | 400                  | 800 CYDS/DAY               |
|      | E. MUCK (EXC. WASTE & BACKFILL)                        |                      | 2000 CYDS/DAY              |
|      | F. EXC. (WIDENING)                                     |                      | 20 STAS/DAY                |
|      | G. GRADING (G&DS)                                      |                      | 25 STAS/DAY                |
|      | H. SUBBASE AND SEL SUB (24' OR LESS)                   |                      | 20 STAS/DAY                |
|      | I. SUBBASE AND SEL SUB (MORE THAN 24' )                |                      | 15 STAS/DAY                |
|      | K. SUBGRADE UNDERCUT AND BACKFILL                      |                      | 2000 CYDS/DAY              |
|      | L. SUBBASE AND OPEN GRADED DRAINAGE COURSE             |                      | 15 STAS/DAY                |

Figure 3.11 Standard Productivity Rates (Michigan)



officials to determine a more predictable contract duration for jobs of various sizes. Figures 3.12 and 3.13 are representative of this method.

An additional concern when basing contract durations on production rates is that the rates used will determine the qualifications needed by the contractor to complete the work within the allotted time. To insure reliable bids, care and sound judgement must be exercised when selecting these rates.

There are also differing opinions among the states as to the period of time that production rate data is accumulated. Where some agencies believe that production rates used in determining contract durations should be based on recent data to reflect advances in technology, others believe that "state-of-the-art" production rates could hinder those contractors that might use older equipment.

In the interest of comparing various production rates used by state agencies across the country, Appendix A is a tabulation of standard production rates used in determining working-days from 12 respondents who provided these values in the survey. Work item categories varied significantly from one state to the next so in many cases similar work items were grouped together to facilitate comparison. Many categories were unique to just one or two states, but were still included to show their existence. In fact, unique work categories appeared to be more common than similar



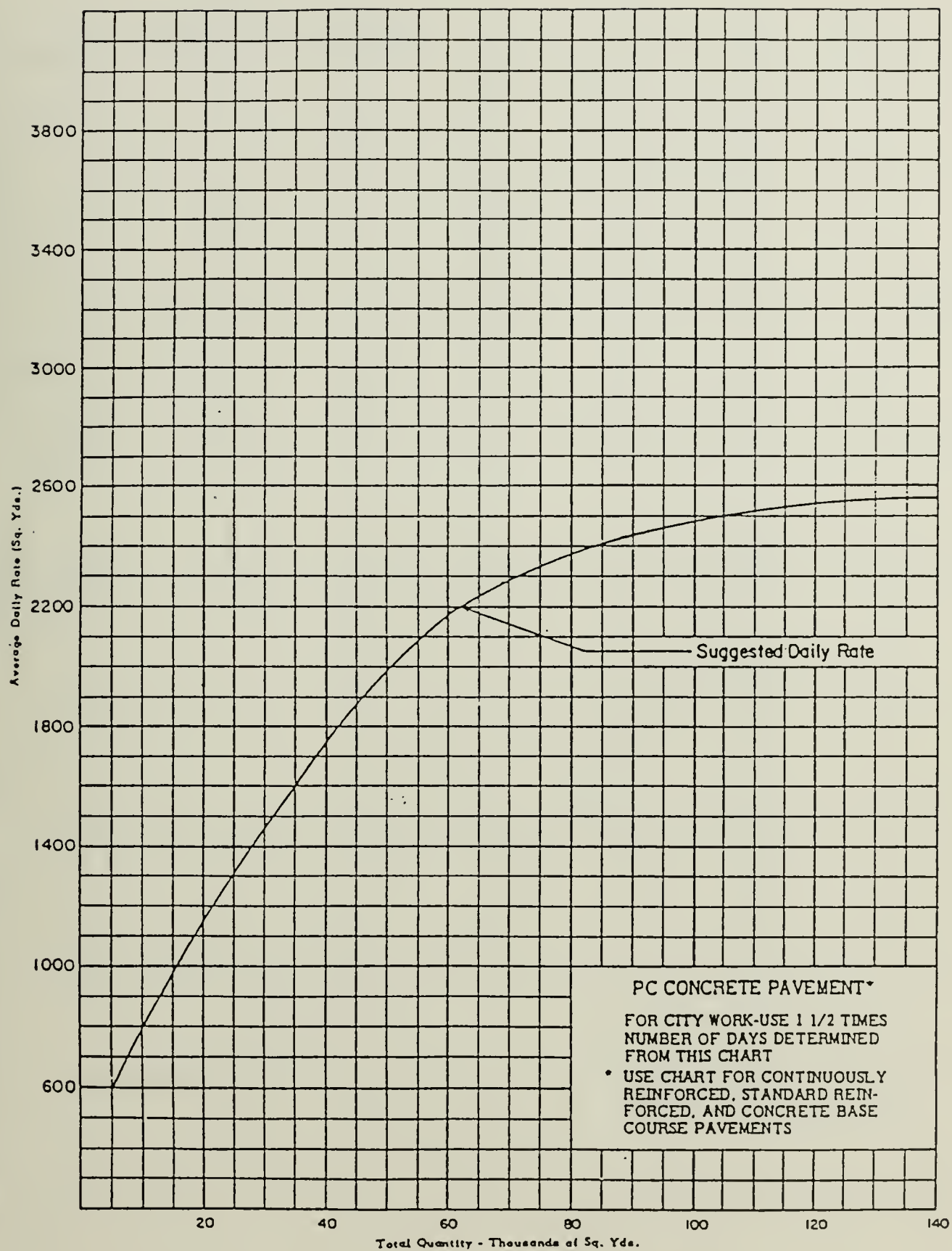


Figure 8-501.02b

Figure 3.12 Productivity Curve (Illinois)





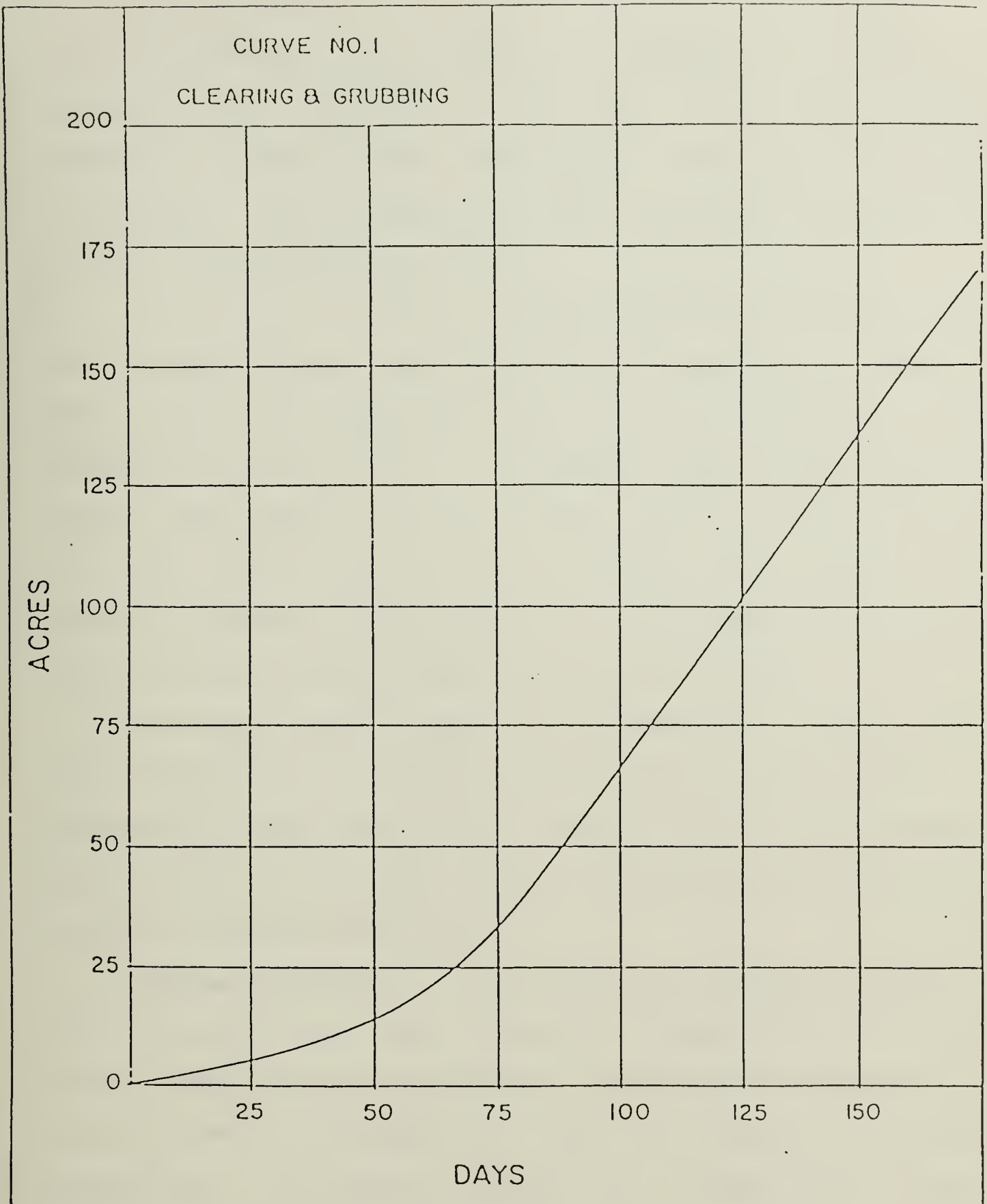


Figure 3.13 Productivity Curve (Louisiana)



work categories. The tables in Appendix A contain 81 separate work categories which were culled from several hundred standard work activities used by the states responding. Some categories were identical to others in scope, only differing by title.

It is obvious when comparing productivity rates from the various states that each state, in many cases, seems to have a different interpretation of what a particular work category includes. In some instances the analogy of mixing apples and oranges is appropriate. This is especially true with the items that include earthwork and paving. For instance, "base" is considered a bituminous layer by most agencies, but a crushed aggregate layer by others.

Further, not only do production rates vary significantly in several categories, but the units of measurement also vary. For example, most states measure paving in tons per day while Michigan measures this work category in stations per day.

Another variance is the type or size of project to which a particular work category is applied. Some of the states apply varying production rates based on whether the job is "small" or "large", or "rural" or "urban". No further explanation is usually provided for these distinctions. These contrast with states that divide projects up into several types. North Carolina, for example, has six standard project categories:



- Major Urban and Rural Projects
- Grading & Paving Projects
- Paving Projects
- Small Rural Widening Projects
- Small Urban Projects-Grading and Paving
- Resurfacing and Surfacing

The only distinctions offered for these differing project categories, however, is that the "Major Urban and Rural Projects" category applies to jobs with grading in excess of 1,000,000 cubic yards, the "Grading & Paving Projects" category applies to jobs with less than 1,000,000 cubic yards, and the "Small Urban Projects-Grading and Paving" category applies to both widening and new location jobs. As with the majority of information provided by the survey respondents, further interpretation is left to the reader.

The use of productivity rates is almost always combined with a work-flow method to determine expected contract duration. In most cases, overlapping work-items are taken into consideration when calculating contract time, however, in some cases, states simply add calculated durations of each controlling work-item as if they were unaffected by other work. This procedure can often lead to excessive contract time allowed in a contract.



## Work-Flow Techniques

Although many forms of scheduling techniques exist, the methods most widely used by state agencies are bar charts and/or the critical path method. Often the type of scheduling method used is dependent upon the complexity of the project in question.

Bar charts are favored by many state agencies because of the ease in which all parties involved in the construction process can readily understand them and determine progress on the job. They are also easily understood by those not involved in construction which is an advantage when using a schedule as evidence in court.

A typical bar chart used by the state of Indiana is shown in Figure 3.14. As can be seen from this figure, a significant amount of scheduling information can be presented in a simple and clear manner. These type of charts generally include the number and description of each activity along with each activity's quantity of work and daily productivity rate and early start and early finish dates. The critical path can easily be shown by high-lighting, or other means, and float times can also be shown in a similar manner.

A drawback in the use of bar charts, however, is the inability of those using them to easily determine activity dependencies. To aid in better understanding bar charts, dependencies, along with duration, early start, early





CONTRACT Bridge Project - Sheet 1

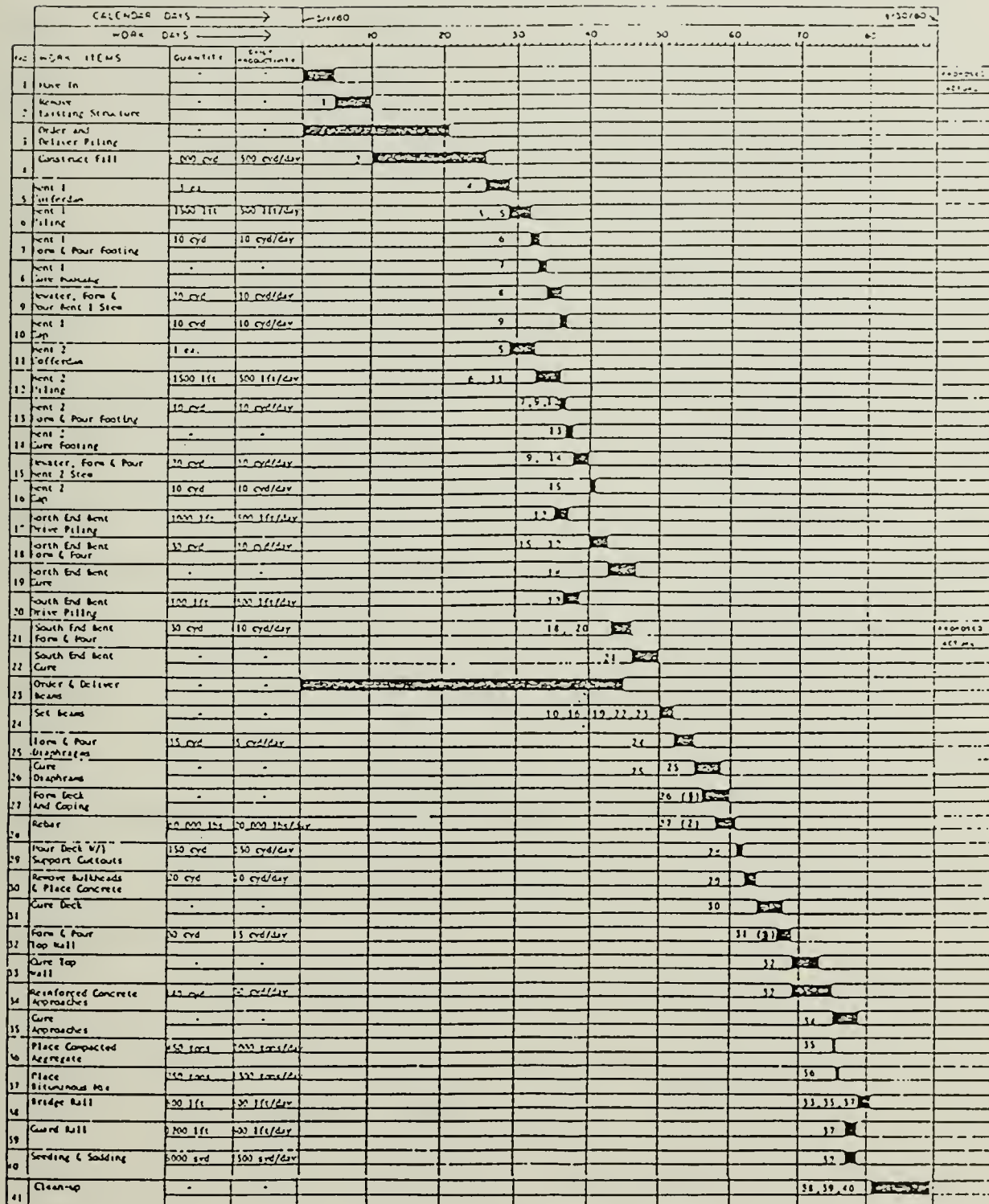
PROJECT \_\_\_\_\_  
DIST. 1 \_\_\_\_\_LETTING DATE \_\_\_\_\_  
START DATE Jan 1, 1961  
COMPLETION DATE \_\_\_\_\_PAGE 01  
D-DRAWN BY \_\_\_\_\_  
APPROVED BY \_\_\_\_\_

Figure 3.14 Highway Project Bar Chart (Indiana)



finish, late start, late finish, and total float times, as well as critical path notations, are quite often tabulated and used as a supplement to the bar chart.

An answer to the problem of not being able to quickly and easily determine activity dependencies for a project is solved with the use of network scheduling. The critical path method (CPM) is a network scheduling technique that clearly displays, in a schematic form, dependencies an activity has on any other activities in a project. This method of determining contract duration is most useful for large, complicated projects that require extensive coordination of materials, equipment, personnel, and administrative support. Because it does not show job progress as readily as a bar chart might, bar charts are often used in conjunction with CPM diagrams. Although several states use the critical path method for major projects, only seven state agencies use CPMs regularly.

As with most scheduling techniques, several distinct CPM methods exist. The most prevalent method used by state agencies is arrow diagramming. Information on the basic elements of CPM by arrow diagramming is given in Appendix C.<sup>24</sup> Figure 3.15, as supported by information in Figure 3.16, further illustrates the use of this method. As can be seen in Figure 3.16, determining activity dependencies, when using this method, is a relatively simple matter.



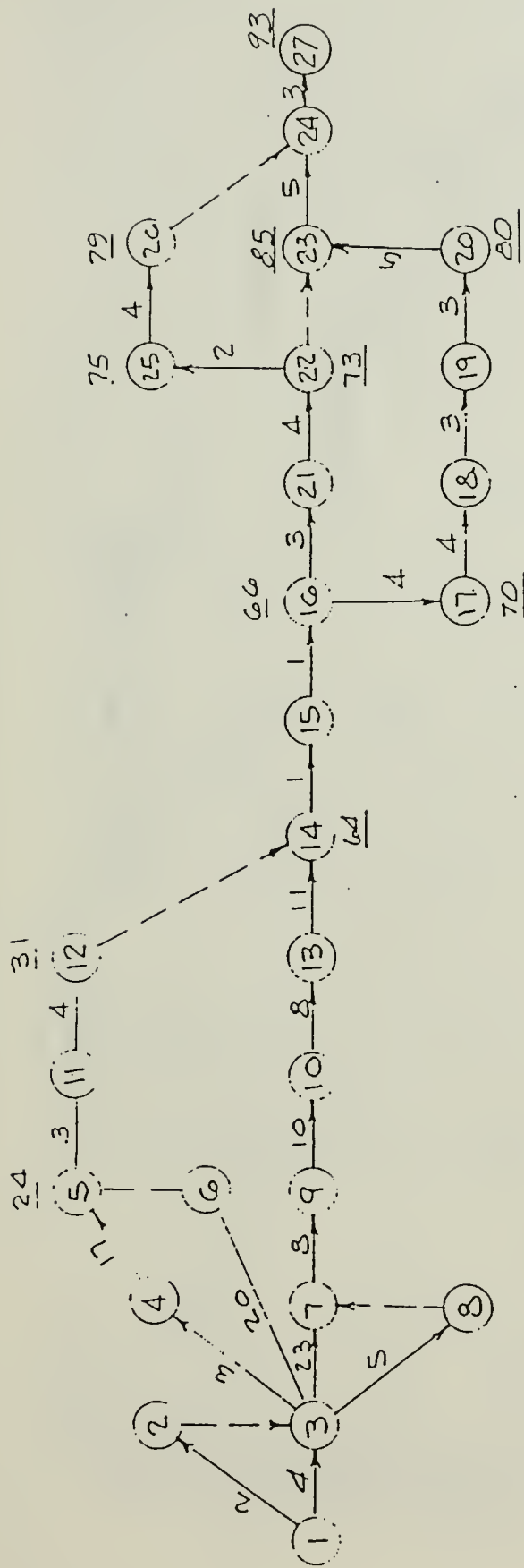


Figure 3.15 CPM Network (Missouri)

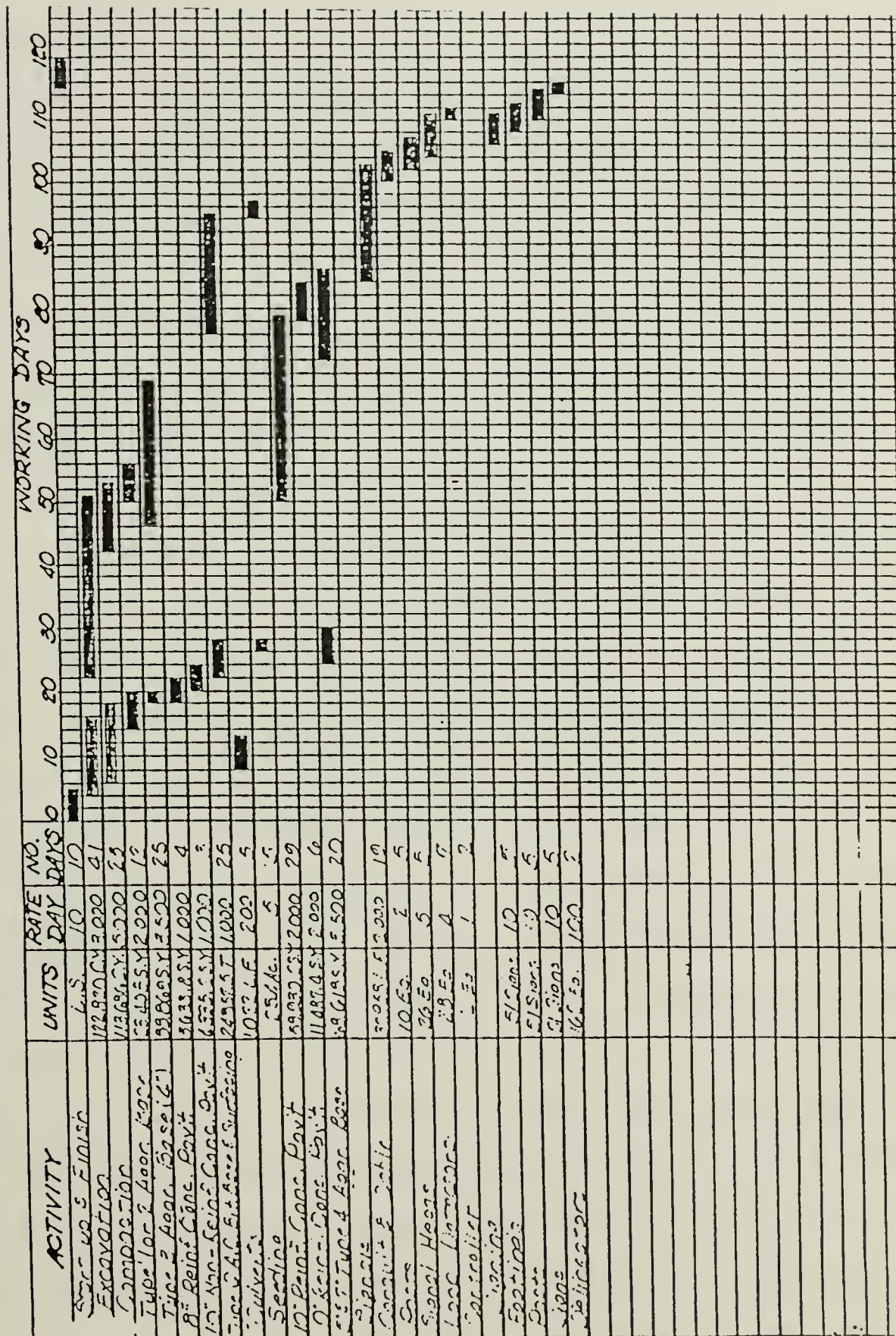
CRITICAL PATH — WORKING DAYS ~ 93 DAYS

Route 37  
Barry County  
Job No. 7-P-37-312





# WORKING DAYS SCHEDULE







## Estimated Costs

Another method used by some state agencies in determining contract durations is based on the estimated costs of projects. With the idea that more costly projects will require more time, and vice-versa, contract durations are established accordingly. Although some agencies only use this method of contract time determination for smaller or less complicated projects, some use it exclusively for certain type jobs, regardless of size.

A method such as this requires a considerable amount of data gathering based on location and type of work in order for it to be effective. Data compiled by New Mexico on grading and paving projects, and by Washington D.C. on structural projects is shown in Figure 3.17.<sup>25</sup>

The graph in Figure 3.18 was developed by the State of Idaho Transportation Department. In developing this graph, Idaho broadly classified several bands of work and project terrains, and used working days for the ordinate and dollars for the abscissa. Establishment of the bands was from calculations based on statistical data, and this particular chart has seen no major changes since it was first published in 1981. In addition to the time period derived from this figure, Idaho officials adjust the contract time depending on the time of year the contract is awarded and any seasonal limitations.



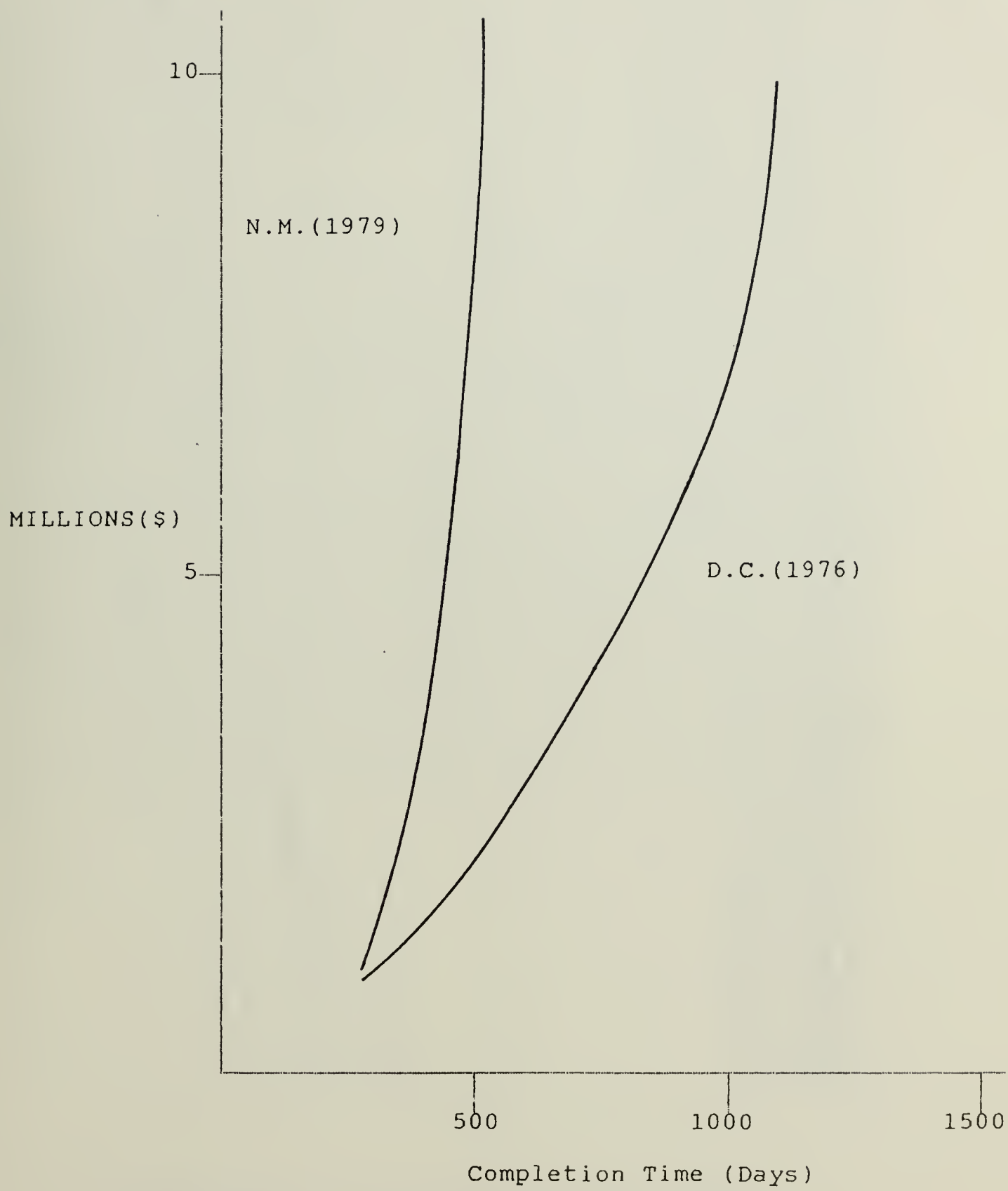


Figure 3.17 Cost-vs-Completion Time Curves (New Mexico, Washington D.C.)







In Oklahoma, when only the program amount for a project is available, a "guesstimate" of working days is made from values found in Figure 3.19.

#### Other Methods

While the vast majority of state agencies use one of the previously discussed methods for determining contract durations, or more likely a combination of these methods, there are some methods that stand apart.

After research at Mississippi State University, J.H. Oswalt, L.R. Johnson, and D.G. Hotard submitted their report *A Method to Determine Contract Work Days-Implementation* in 1975 to the Mississippi State Highway Department, in cooperation with the Federal Highway Administration, which contained the development of a computer-generated procedure for estimating work time and for reporting and monitoring contractor progress. In this system, time units are used as the measure of work with each month having an assigned number of time units available depending on the type of work. A brief description of the Mississippi procedure taken from Transportation Research Board Special Report 79, is given in Appendix D.

Another method that is not often used is the allowing of contractors to play a role in the selection of contract completion dates. In some Washington D.C. projects, the choice of two different contract durations is presented to





## GUESSTIMATE

### RULE OF THUMB FOR WORKING DAYS WHEN ONLY PROGRAM AMOUNT IS AVAILABLE

#### Grading and Drainage Projects

|                                   |                       |
|-----------------------------------|-----------------------|
| Under \$100,000 (Minimum 30 days) | \$1,000/day           |
| \$100,000 to \$200,000            | \$1,250/day + 10 days |
| \$200,000 to \$300,000            | \$1,500/day + 10 days |
| Over \$300,000                    | \$2,000/day + 10 days |

#### Grading, Drainage, & Dustless Type Surface Projects

|                                   |                       |
|-----------------------------------|-----------------------|
| Under \$100,000 (Minimum 40 days) | \$1,500/day           |
| \$100,000 to \$200,000            | \$2,000/day + 10 days |
| \$200,000 to \$300,000            | \$2,500/day + 10 days |
| Over \$300,000                    | \$3,000/day + 10 days |

#### Dustless Surface Projects

|                                   |                       |
|-----------------------------------|-----------------------|
| Under \$200,000 (Minimum 40 days) | \$3,000/day + 10 days |
| Over \$200,000                    | \$3,500/day + 10 days |

Figure 3.19 Contract Duration Estimate By Project Cost  
(Oklahoma)



contractors; the lowest valid bid by either date is accepted by the agency. In Mississippi, one project was awarded based on different completion dates included by contractors in their bids. Increased road user costs on the job were calculated at \$7,000 per day, so to determine the low bidder, the number of contract days submitted by contractors was multiplied by \$7,000 and added to the contractors' dollar amounts for the job. The four low bidders for the project are presented in the table below. As can be seen in the table, the apparent low bidder (with 151 days) did not have the lowest dollar amount, however, after including road user costs, he was low overall. When administering the contract, the \$7,000 per day road user cost was added to the amount normally charged for liquidated damages.

Table 3.1 - Low Bidder Calculation (Mississippi)<sup>26</sup>

| Bidder | Direct Work     | No. Days  | Total Work and      |
|--------|-----------------|-----------|---------------------|
|        | Total Items(\$) | @ \$7,000 | Days Comparison(\$) |
| 1      | 4,721,599.82    | 151       | 5,778,599.82        |
| 2      | 4,544,930.31    | 250       | 6,294,930.41        |
| 3      | 5,271,196.81    | 212       | 6,755,196.81        |
| 4      | 5,215,617.29    | 266       | 7,077,617.24        |



CHAPTER IV  
REPRESENTATIVE METHODS FOR DETERMINING  
CONTRACT DURATION

A. General.

Although the methods used by state transportation agencies in determining contract durations can be grouped into similar types, the following sections of this chapter illustrate that each and every organization has its own procedure that is unique in some way.

ALABAMA

Alabama is typical of those states that rely heavily on the experience of their personnel in determining contract durations. Considerations in determining contract time include the anticipated contract dollar amount, traffic conditions, location, and individual items of work in the project. Work item production rates are not considered in this process.

With the factors that are considered, the determination is made as to how many construction seasons or partial seasons may be needed to complete the work. This process is



followed independently by the Construction Bureau and the Construction Division within the Alabama Highway Department, and after discussion between the two, a contract time is agreed upon.

## ARKANSAS

The determination of contract durations by the Arkansas State Highway and Transportation Department is based on standard work item productivity rates. With the use of these rates, and a work item quantity breakdown such as that shown in Figure 4.1, a bar chart is generated showing the logical progression of work in work days (see Figure 4.2). With the number of work days calculated from the bar chart, the corresponding number of calendar days is established by comparing the number of work days necessary to complete the work to the allotted number of work days per month by zone as determined by geographical location and type of work (see Figure 4.3) and the number of calendar days per month.

In the process of the work, working days are defined as days on which the weather, condition of the ground, or the condition of the materials being used are such that the contractor can employ 60% of his forces and equipment to prosecute the work required at that time in the regular sequence of operations as determined by the Resident Engineer.





ARKANSAS STATE HIGHWAY AND TRANSPORTATION DEPARTMENT

JOB R10013

WITTSBURG-HWY. 64 (BASE & SURFACE)

STATE JOB

The proposed project consists of approximately 2.011 miles of Reconstructed Base Course, Bank Gravel Base Course, Bituminous Surface Treatment (Shoulders), Asphaltic Concrete Hot Mix Surface Course and Misc. Items on the Wittsburg-Hwy. 64 Base and Surfacing Project, State Highway 163, Section 1, Cross County.

It begins at the intersection of Hwy. 64 and Hwy. 163 and extends south 2.20 miles including 0.189 mile exception.

The following items and approximate quantities are involved:

|       |       |                                   |
|-------|-------|-----------------------------------|
| 92    | Stas  | Reconst.Base Crse.                |
| 1662  | CuYds | Bank Gravel Base Crse.            |
| 14058 | Gals  | Prime Coat                        |
| 257   | Gals  | Tack Coat                         |
| 331   | CuYds | Min.Aggr.in Bit.Surf.Trmt.(Cl.10) |
| 7929  | Gals  | Asph.in Bit.Surf.Trmt.            |
| 2816  | Tons  | Min.Aggr.in ACHM Surf.Crse.(Ty.2) |
| 164   | Tons  | Asph.Cem.in ACHM Surf.Crse.       |
| 1     | L.S.  | Maint.of Traffic                  |
| 114   | SqFt  | Signs                             |
| 1063  | LinFt | Temp.Pvmt.Mkgs.                   |
| 1     | L.S.  | Mobilization                      |

The successful bidder will be required to complete this contract on or before November 19, 1986.

Figure 4.1 Proposed Project Work Items (Arkansas)

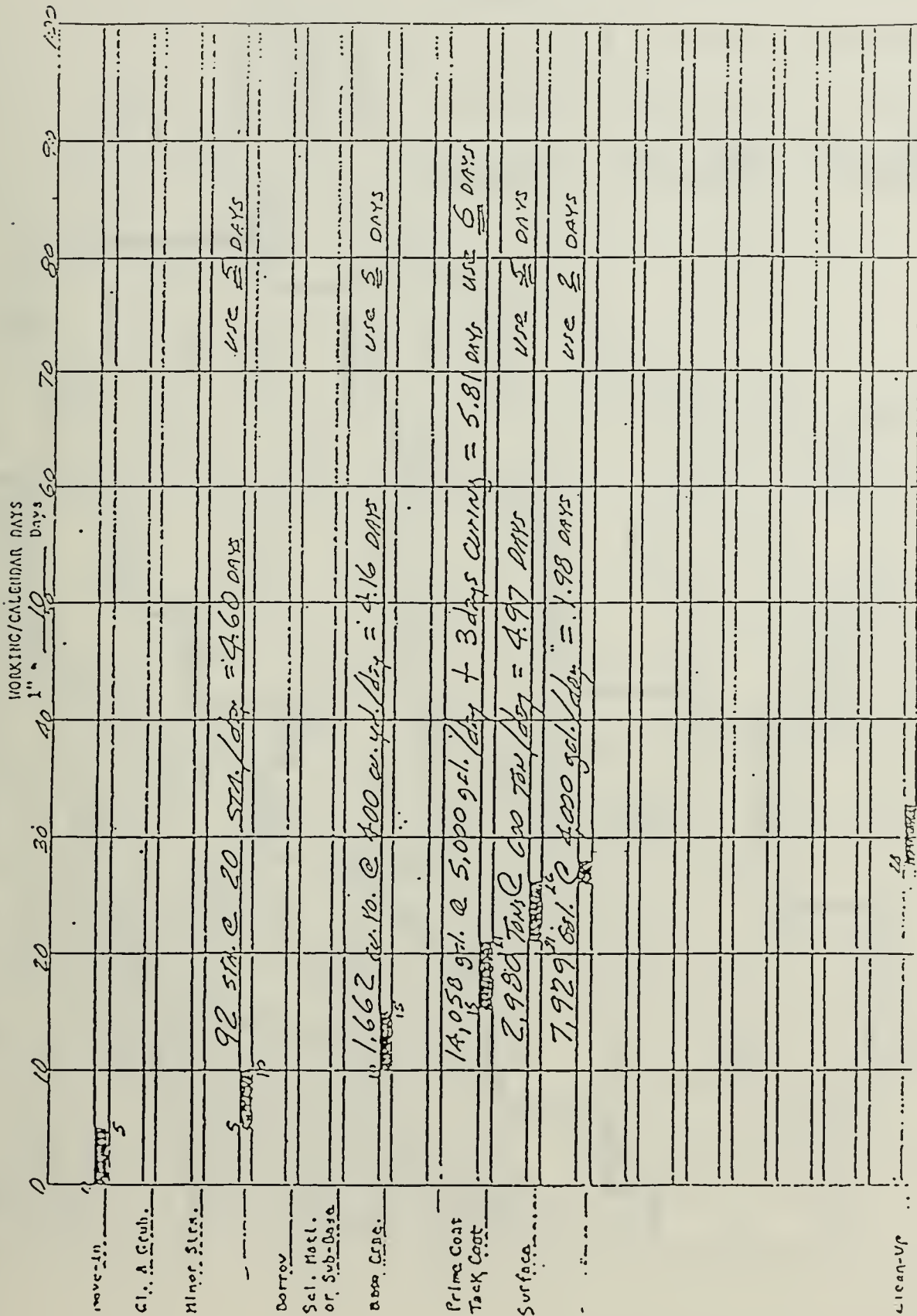


ESTIMATE OF TIME

1844

107. 1821





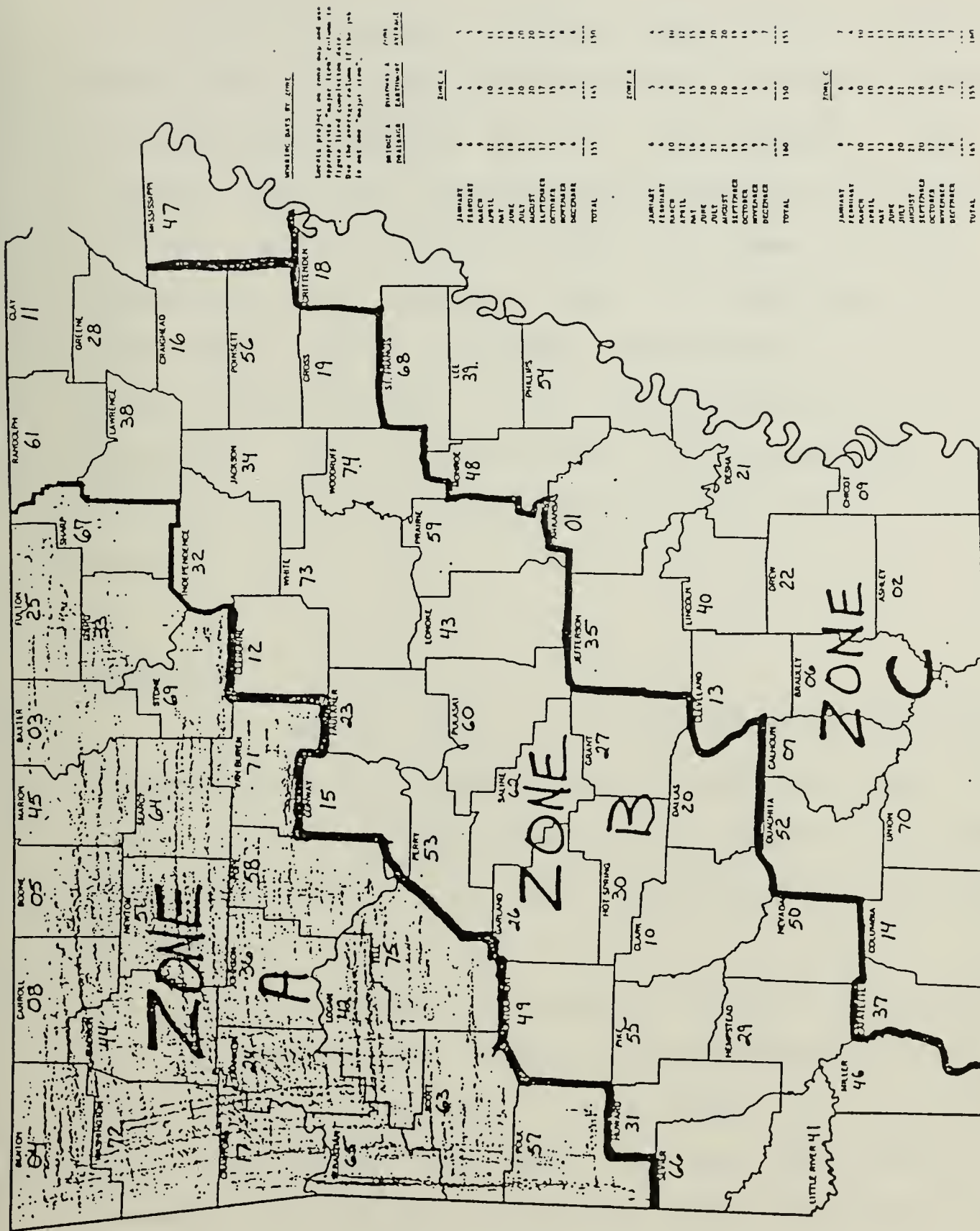


Figure 4.3 Work Day Zone Chart (Arkansas)



Once the number of calendar days needed for the work is established, a fixed completion date is determined based on an estimated starting date of the project. When other factors, such as seasonal limitations, utility adjustments, projects with specialty items, or jobs on which quick completion is desired, are of importance, the fixed completion date is adjusted accordingly. It is only this fixed completion date that the contractor sees in proposal documents; he is responsible for establishing his own progress schedule for completing the work within the allotted time.

#### MARYLAND

The method used by the Maryland Department of Transportation in determining contract durations is very similar to that used in Arkansas; production rates based on historical data are the foundation of contract time determination.

Using the Engineer's project estimate, controlling work item quantities are divided by standard productivity rates which provide "unadjusted" work days for each work item. These unadjusted work days are then multiplied by the "Average Overlap %" to determine adjusted work days for each work item. This value is the average amount of time, based on historical data, that work items are considered controlling







versus overlapping. Figure 4.4 displays these values for various work items and shows how adjusted work days are computed.

After adjusted work days have been calculated, consideration is given to construction seasons. To do this, the adjusted work days are charted on a bar chart (see Figure 4.5) based on the anticipated Notice to Proceed date and the average number of work days per region depending on the type of job, as shown in Figure 4.6. This enables the estimator to foresee if certain items of work might be delayed due to temperature or weather restrictions, or other limiting conditions.

Other considerations include:

- Lead time needed for approval of plans, shop drawings, and pile hammers
- Time for fabrication of structural steel and other specialty items
- Curing time and waiting periods between successive paving courses and between concrete placement operations, as well as specified embankment settlement periods
- Conflicting operations of adjacent projects both public and private
- Necessity for coordination of road construction with utility construction or relocation, when indicated in contract provisions



## OVERLAP/SPECIAL CONDITIONS

| <u>OPERATION</u>                        | <u>*AVERAGE<br/>OVERLAP</u> | <u>SPECIAL CONDITIONS</u>                                     |
|---|-----------------------------|---|
| Preliminary/Prep Time                   | 100%                        | Max. 10 Days  |
| Grading                                 | 70%                         | Usually includes drainage                                     |
| Drainage                                | 0-25%                       | Drainage items are usually completed during grading.          |
| <u>STRUCTURES</u>                       |                             |   |
| Excavation                              | 25%                         |   |
| Piling                                  | 25%                         |   |
| Footing Concrete                        | 25%                         |   |
| Substructure                            | 75%                         |   |
| Struct. Steel                           | 75%                         | Minimum 150 CD required to fabricate & furnish struct. steel. |
| Superstructure                          | 100%                        |   |
| Deck Coatings                           | 100%                        |   |
| <u>PAVING</u>                           | 70%                         | Resurface = 100%  |
| <u>SHOULDERS</u>                        | 70%                         | Resurface = 100%  |
| <u>LANDSCAPING</u>                      | 100%                        |   |
| <u>UTILITIES (included in contract)</u> |                             |   |
| Water, Sewage                           | 0                           |   |
| Lighting, Signing, Signals              | 0 - 50%                     |   |
| <u>CLEANUP, FINALIZE PROJECT</u>        | 100%                        | Max. 10 Days  |

\*No. of adjusted work days = No. of unadjusted work days x Average Overlap (controlling %)

where the no. of unadjusted work days =  $\frac{\text{plan quantity}}{\text{productivity rate}}$

(Convert controlling % to decimal by dividing by 100 before multiplying))

Ex.  $\frac{120 \text{ C.Y.}}{15 \text{ C.Y./day (Productivity rate)}} = 8 \text{ unadjusted work days}$

8 unadj. work days x .25 (25% controlling %) = 2 adjusted workdays

Figure 4.4 Average Overlap Values (Maryland)



## CONTRACT TIME ESTIMATE

| Contract No.<br>AW-532 - 752-677 /<br>FAP No.<br>85 - 100(1) | Type<br>CONSTRUCTION | Region<br>WESTERN | Description<br>DUAL STRUCTURES - US ROUTE<br>69 OVER MD 626 | Advertisement Date<br>3/8/84<br>Anticipated NTP<br>7/3/84 | Estimated Cost<br>\$4,378,251.00<br>Date of Request<br>2/15/84 | By<br>KCU<br>Date<br>2/21/84 |
|--|----------------------|-------------------|---|---|--|------------------------------|
| Activity   | Quantity             | Unit              | Units /<br>Workday  | Unodi.<br>Work<br>Days                                    | %Over-<br>lap %  | Adj.<br>Work<br>Days         |
| PRE-TIME   |                      | LS                |   | 10  | 100  | 10                           |
| CLASS II   | 193,900              | CY                | 7,000   | 28  | 0  |                              |
| BORROW   | 493,000              | CY                | 5,000   | 99  | 25   | 25                           |
| PIPE   | 1,914                | LF                | 60  | 32  | 0  |                              |
| ENDWALLS & INLETS  | 39                   | EA                | 0.5   | 78  | 5  | 4                            |
| PILING   | 10,170               | LF                | 350   | 29  | 25   | 8                            |
| FOOTING CONCRETE   | 1,330                | CY                | 20  | 66  | 50   | 33                           |
| SUBSTRUCTURE CONC.   | 1,100                | CY                | 20  | 55  | 75   | 41                           |
| STRUCTURAL STEEL   | 147.5                | T                 | 10  | 15  | 75   | 11                           |
| SUPERSTRUCTURE CONC.   | 280                  | CY                | 15  | 14  | 100  | 14                           |
| 6" SUBBASE   | 23,650               | SY                | 2,500   | 9   | 70   | 6                            |
| BC BASE  | 4800                 | T                 | 450   | 11  | 70   | 8                            |
| BC SURFACE   | 4,050                | T                 | 450   | 9   | 70   | 6                            |
| STABILIZED SHOULDER  | 33,200               | SY                | 3000  | 10  | 70   | 7                            |
| BC SHOULDER BASE   | 200                  | T                 | 50  | 4   | 70   | 3                            |
| BC SHOULDER SURFACE  | 2800                 | T                 | 375   | 7   | 70   | 5                            |
| GUARD RAIL   | 5875                 | LF                | 1000  | 6   | 70   | 4                            |
| TOP SOIL   | 1850                 | CY                | 800   | 2   | 100  | 2                            |
| SEED & MULCH   | 1,700                | LBS               | 500   | 3   | 100  | 3                            |
| POST-TIME  |                      | LS                |   |   |  | 10                           |
| Total Work Days  |                      |                   |   |   | 200  |                              |
| Total Calendar Days  |                      |                   |   |   |  |                              |
| * Controlling %  |                      |                   |   |   |  |                              |

Form SHA 72.1-23A (5-23-83)  
 MARYLAND STATE HIGHWAY ADMINISTRATION

Figure 4.5 Contract Time Estimate (Maryland)



AVERAGE NUMBER OF WORKING DAYS ON CONSTRUCTION CONTRACTS

|           | <u>SOUTH/EASTERN MD.</u> |              | <u>CENTRAL MARYLAND</u> |              | <u>WESTERN MARYLAND</u> |              |
|-----------|--------------------------|--------------|-------------------------|--------------|-------------------------|--------------|
|           | <u>Bridges</u>           | <u>Roads</u> | <u>Bridges</u>          | <u>Roads</u> | <u>Bridges</u>          | <u>Roads</u> |
| January   | 8                        | 5            | 4                       | 4            | 4                       | 2            |
| February  | 8                        | 5            | 5                       | 5            | 4                       | 2            |
| March     | 11                       | 8            | 9                       | 8            | 5                       | 4            |
| April     | 14                       | 15           | 15                      | 15           | 14                      | 13           |
| May       | 18                       | 14           | 16                      | 18           | 16                      | 15           |
| June      | 18                       | 17           | 18                      | 19           | 16                      | 18           |
| July      | 19                       | 17           | 19                      | 18           | 19                      | 17           |
| August    | 18                       | 18           | 20                      | 18           | 19                      | 17           |
| September | 18                       | 18           | 19                      | 17           | 18                      | 18           |
| October   | 19                       | 18           | 19                      | 18           | 16                      | 16           |
| November  | 16                       | 13           | 15                      | 16           | 10                      | 10           |
| December  | 10                       | 9            | 10                      | 8            | 2                       | 4            |
| TOTAL     | 177                      | 157          | 169                     | 164          | 143                     | 136          |

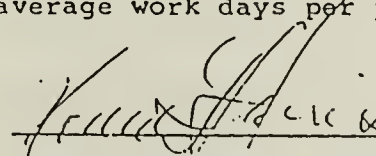
Calvert  
Charles  
Caroline  
Dorchester  
Kent  
Prince George's  
Queen Anne's  
St. Mary's  
Somerset  
Talbot  
Wicomico  
Worcester

Baltimore  
Cecil  
Carroll  
Frederick  
Harford  
Howard  
Montgomery  
Washington  
Anne Arundel

Garrett  
Allegany

The region into which borderline counties are categorized may vary depending upon job location within the county. Use average work days per pertinent region accordingly.

Effective Dec. 19, 1983

  
\_\_\_\_\_  
Norman G. Harris, Chief

Bureau of Construction Inspection

December 17, 1984

Figure 4.6 Average Number of Working Days by Location and Job Type (Maryland)







- Duration of disruption to traveling public caused by construction
- Duration of delay in providing relief for heavily congested routes
- Schedule of work on alternate routes
- Loss of revenue to businesses within affected areas
- Timely response of emergency vehicles
- Cost of the project
- Cash flow of the State Highway Administration

From experience, Maryland officials have determined that the most benefit is achieved, in almost all situations, by allowing the least amount of time for contract completion based on average productivity rates. The time allowed in Maryland contracts is almost always in working days, however, for major projects of a sensitive nature, construction time is by specified completion date. In this situation, increased productivity rates are used in anticipation of an accelerated construction schedule which might require the use of multiple shifts and crews, weekend work, etc.

Finally, aside from those considerations given to the unique characteristics of each project, it is felt by Maryland officials that sound engineering judgement is of the utmost importance in the estimation of allowable contract time.



## PENNSYLVANIA

Contract durations for ninety-five percent of all projects in Pennsylvania are determined with the aid of a computer generated bar chart. Input by the users of the computer program "Construction Estimator" includes the work days of each operation as calculated from anticipated quantities and productivity rates, the anticipated Notice to Proceed date of the contract, the work activity logic, and a working day calendar based on location and whether or not the project is standard (135 work days/year), accelerated (180 work days/year), or slow (102 work days/year). The input for the working day calendar is shown in Figure 4.7.

The output generated by the computer software consists of a conversion chart of work days to calendar days (see Figure 4.8), and a final calendar day bar chart, as shown in Figure 4.9, which is included in the contract bid proposal for informational purposes in the majority of construction contracts let by the agency.

For projects which are large and complex, and in highly urbanized areas, Critical Path Method (CPM) charts are provided to the Pennsylvania Department of Transportation by design consultants hired by the Department. These type contracts also sometimes include incentive/disincentive clauses for intermediate milestone dates, and increased liquidated damages for contractor failure to meet contract completion dates. Because department personnel have only limited knowledge of CPM, construction management consultants



\*\*\*\*\*  
 W O R K I N G    D A Y    C A L E N D A R S  
 \*\*\*\*\*

| filename<br>-----  | working days/month<br>----- |          |           |           |           |           |           |           |           |           |           |          |
|--|-----------------------------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|
|  | JAN                         | FEB      | MAR       | APR       | MAY       | JUN       | JUL       | AUG       | SEP       | OCT       | NOV       | DEC      |
| STD135   | 2                           | 2        | 7         | 12        | 18        | 18        | 18        | 18        | 18        | 15        | 5         | 2        |
| STDBR<br>(standard bridge)   | JAN<br>5                    | FEB<br>5 | MAR<br>10 | APR<br>14 | MAY<br>18 | JUN<br>18 | JUL<br>18 | AUG<br>18 | SEP<br>18 | OCT<br>15 | NOV<br>10 | DEC<br>5 |
| STD180<br>(accelerated)  | JAN<br>6                    | FEB<br>6 | MAR<br>11 | APR<br>16 | MAY<br>21 | JUN<br>20 | JUL<br>21 | AUG<br>21 | SEP<br>20 | OCT<br>18 | NOV<br>12 | DEC<br>8 |
| STD109<br>(signals/lighting)   | JAN<br>8                    | FEB<br>8 | MAR<br>11 | APR<br>16 | MAY<br>21 | JUN<br>20 | JUL<br>21 | AUG<br>21 | SEP<br>20 | OCT<br>18 | NOV<br>15 | DEC<br>8 |
| SLOW1-0<br>(reduced Dist. 1-0)   | JAN<br>1                    | FEB<br>1 | MAR<br>1  | APR<br>3  | MAY<br>12 | JUN<br>17 | JUL<br>17 | AUG<br>15 | SEP<br>15 | OCT<br>13 | NOV<br>6  | DEC<br>1 |
| NORTH2-0<br>(Elk. Cameron,<br>North Centre,<br>North Clinton,<br>Clearfield) | JAN<br>0                    | FEB<br>0 | MAR<br>2  | APR<br>6  | MAY<br>11 | JUN<br>15 | JUL<br>15 | AUG<br>15 | SEP<br>15 | OCT<br>13 | NOV<br>9  | DEC<br>2 |
| SOUTH2-0<br>(Mifflin,<br>South Centre,<br>South Clinton)                     | JAN<br>2                    | FEB<br>2 | MAR<br>5  | APR<br>7  | MAY<br>12 | JUN<br>16 | JUL<br>16 | AUG<br>16 | SEP<br>16 | OCT<br>14 | NOV<br>10 | DEC<br>2 |
| MCKPOT<br>(McKean. Potter)   | JAN<br>0                    | FEB<br>0 | MAR<br>2  | APR<br>5  | MAY<br>8  | JUN<br>14 | JUL<br>14 | AUG<br>14 | SEP<br>14 | OCT<br>10 | NOV<br>5  | DEC<br>2 |
| CLAJEF<br>(Clarion. Jefferson)   | JAN<br>2                    | FEB<br>2 | MAR<br>4  | APR<br>5  | MAY<br>16 | JUN<br>18 | JUL<br>18 | AUG<br>18 | SEP<br>11 | OCT<br>9  | NOV<br>5  | DEC<br>2 |

Figure 4.7 Working Day Calendar (Pennsylvania)



# CONVERSION OF WORKING DAYS TO CONSECUTIVE CALENDAR DAYS

BY: JEB

DATE: 06-16-1987

\*\*\*\*\*

CONTRACT NUMBER: 111203

LETTING: 7 - 30 - 87

COUNTY: ALLEGHENY

NOTICE TO PROCEED: 9 - 14 - 87

ROUTE: 0837 SEC: 52M

START WORK: 9 - 14 - 87

CITY-TWP-BORO: DUQUESNE

HOURS/DAY: 8

FPN: 010-0019-023  
A14-0019-023

DAYS/WEEK: 5

SPN: B 08370852M1110-383

REVISION NO: 00

TRAINEES: Y

\*\*\*\*\*

| OPERATION | WORKING DAYS |     | CALENDAR DAYS |     | TOTAL OPERATION<br>CALENDAR DAYS |
|-----------|--------------|-----|---------------|-----|----------------------------------|
|           | BEGIN        | END | BEGIN         | END |                                  |
| A01       | 0            | 3   | 0             | 5   | 5                                |
| B02       | 4            | 12  | 7             | 21  |                                  |
| B02       | 53           | 54  | 178           | 181 |                                  |
| B02       | 77           | 93  | 235           | 263 |                                  |
| B02       | 103          | 119 | 279           | 306 | 72                               |
| C03       | 79           | 95  | 239           | 266 |                                  |
| C03       | 105          | 121 | 283           | 310 | 54                               |
| D04       | 123          | 129 | 313           | 324 | 11                               |
| E05       | 2            | 51  | 4             | 172 |                                  |
| E05       | 54           | 63  | 181           | 206 |                                  |
| E05       | 66           | 74  | 213           | 230 |                                  |
| E05       | 84           | 99  | 247           | 273 |                                  |
| E05       | 110          | 125 | 291           | 317 |                                  |
| E05       | 139          | 140 | 341           | 343 | 264                              |
| F06       | 4            | 9   | 7             | 15  |                                  |
| F06       | 22           | 34  | 42            | 75  |                                  |
| F06       | 78           | 96  | 237           | 268 |                                  |
| F06       | 104          | 121 | 281           | 310 | 101                              |
| G07       | 15           | 20  | 27            | 38  |                                  |
| G07       | 34           | 38  | 75            | 97  |                                  |
| G07       | 91           | 107 | 259           | 286 |                                  |
| G07       | 117          | 130 | 303           | 325 |                                  |
| G07       | 131          | 137 | 327           | 337 | 92                               |
| H08       | 62           | 68  | 204           | 217 | 13                               |
| I09       | 51           | 142 | 172           | 346 |                                  |
| I09       | 142          | 144 | 346           | 376 | 204                              |
| K11       | 120          | 131 | 308           | 327 | 19                               |
| L12       | 14           | 20  | 25            | 38  |                                  |
| L12       | 38           | 40  | 97            | 109 |                                  |
| L12       | 135          | 138 | 334           | 339 | 30                               |
| M13       | 0            | 143 | 0             | 370 | 370                              |

\*\*\*\*\*

A01T = 1 TO 376

\*\*\*\*\*

Figure 4.8 Work Day to Calendar Day Conversion Chart  
(Pennsylvania)





D-476 DISTRIBUTION OF CONTRACT TIME

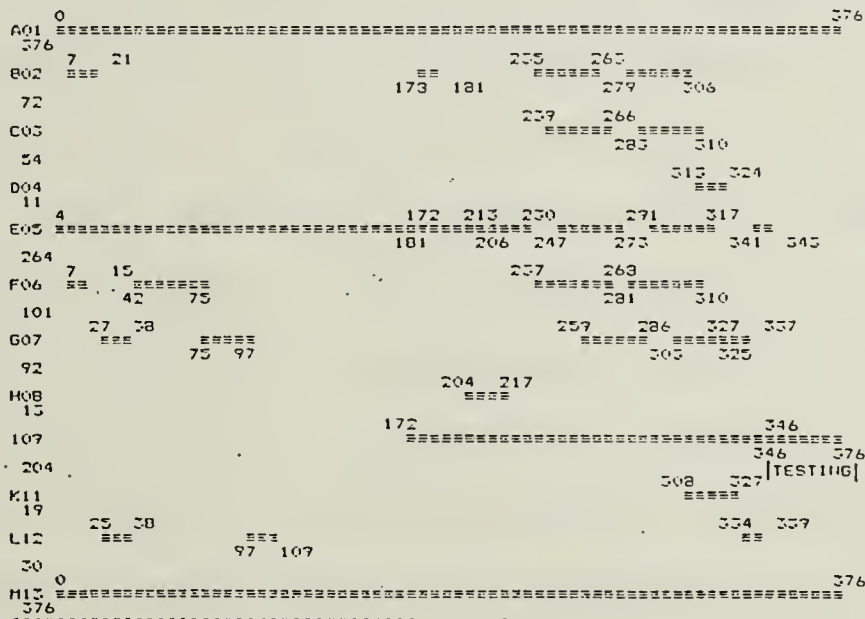
CONTRACT NO: 111205  
COUNTY: ALLEGHENY  
ROUTE: 0037

FED. PROJ. NO.: A14-0019-023  
SECTION: 52H

LETTING DATE: 7 - 30 - 87  
NOTICE TO PROCEED-ANTICIPATED: 9 - 14 - 87  
ACTUAL: \_\_\_\_\_  
CALENDAR DAYS ALLOWED: 376  
WORK DAYS BASED ON 0 HRS/DAY  
APPROVED BY: \_\_\_\_\_

REVISION NO. 00  
SCHEDULE ADJUSTMENT: \_\_\_\_\_  
CONTRACT TIME ADJUSTMENT: \_\_\_\_\_  
DATE REVIEW BY CONTRACTOR: \_\_\_\_\_  
ADJUSTMENT REQUESTED: \_\_\_\_\_

DISTRICT ENGINEER: \_\_\_\_\_ DATE: \_\_\_\_\_  
CHIEF ENGINEER: *Vesker* DATE: 6-25-87



SCHEDULE OF OPERATIONS

CONTRACT NO: 111205

| OPERATION                       | BEGIN DATE   | END DATE     |
|---------------------------------|--------------|--------------|
| A01 PROJECT PREP. & MISC.       | 9 - 14 - 87  | 9 - 23 - 88  |
| B02 EARTHWORK                   | 9 - 20 - 87  | 10 - 4 - 87  |
|                                 | 3 - 9 - 88   | 3 - 12 - 88  |
|                                 | 5 - 5 - 88   | 6 - 2 - 88   |
|                                 | 6 - 18 - 88  | 7 - 15 - 88  |
| C03 SUBBASE                     | 5 - 9 - 88   | 6 - 5 - 88   |
|                                 | 6 - 22 - 88  | 7 - 17 - 88  |
| D04 BITUM. PAVE. & BASE COURSES | 7 - 22 - 88  | 8 - 2 - 88   |
| E05 RIGID PAVEMENT              | 7 - 17 - 87  | 3 - 3 - 88   |
|                                 | 3 - 12 - 88  | 4 - 6 - 88   |
|                                 | 4 - 13 - 88  | 4 - 30 - 88  |
|                                 | 5 - 17 - 88  | 6 - 12 - 88  |
|                                 | 6 - 30 - 88  | 7 - 26 - 88  |
|                                 | 8 - 17 - 88  | 8 - 21 - 88  |
| F06 DRAINAGE                    | 9 - 20 - 87  | 9 - 23 - 87  |
|                                 | 10 - 25 - 87 | 11 - 27 - 87 |
|                                 | 5 - 7 - 88   | 6 - 7 - 88   |
|                                 | 6 - 20 - 88  | 7 - 19 - 88  |
| G07 CURBS & GUTTERS             | 10 - 10 - 87 | 10 - 21 - 87 |
|                                 | 11 - 27 - 87 | 12 - 17 - 87 |
|                                 | 5 - 29 - 88  | 6 - 23 - 88  |
|                                 | 7 - 12 - 88  | 8 - 3 - 88   |
|                                 | 8 - 5 - 88   | 8 - 15 - 88  |
|                                 | 4 - 4 - 88   | 4 - 17 - 88  |
| H08 LANDSCAPING                 | 3 - 3 - 88   | 8 - 24 - 88  |
| I09 TRAFFIC ACC. & CONTROL      | 8 - 24 - 88  | 9 - 23 - 88  |
| K11 SHOULDERS                   | 7 - 17 - 88  | 8 - 5 - 88   |
| L12 GUIDE RAILS, ETC.           | 10 - 8 - 87  | 10 - 21 - 87 |
|                                 | 12 - 17 - 87 | 12 - 31 - 87 |
|                                 | 8 - 12 - 88  | 8 - 17 - 88  |
| M13 TEMP. TRAFFIC ACCOM.        | 9 - 14 - 87  | 9 - 23 - 88  |

Figure 4.9 Final Calendar Day Bar Chart (Pennsylvania)



are retained to monitor and analyze project CPM charts during project construction.

The CPM chart developed by the department's design consultant (see Figure 4.10) is included with the contract bid proposal along with special contract provisions that discuss its use. These provisions state that deviations may be made, upon approval, from the general logic sequence of the Pre-Bid Schedule to suit the sequence preferred by the contractor, however, the contract completion date and the milestone dates in the schedule are considered binding.

As a back-up to the methods discussed above, the Pennsylvania Department of Transportation also prepares additional documents that show the schedule of work for projects. These include a "Straight-Line Diagram and Analysis of Operations" (see Figure 4.11), and a work day bar chart as shown in Figure 4.12. The first document includes a diagram that shows the limits of work by stations, quantities and productivity rates of project work items, the construction sequence of the project, and the duration of each work item in work days. The second document summarizes the work item information from the first in the form of a bar chart.

One important aspect of this process that was not made clear in the Pennsylvania DOT survey response is the manner in which productivity rates are determined. It appears from the information provided that the determination of these values is left to the discretion and experience of individual District offices.



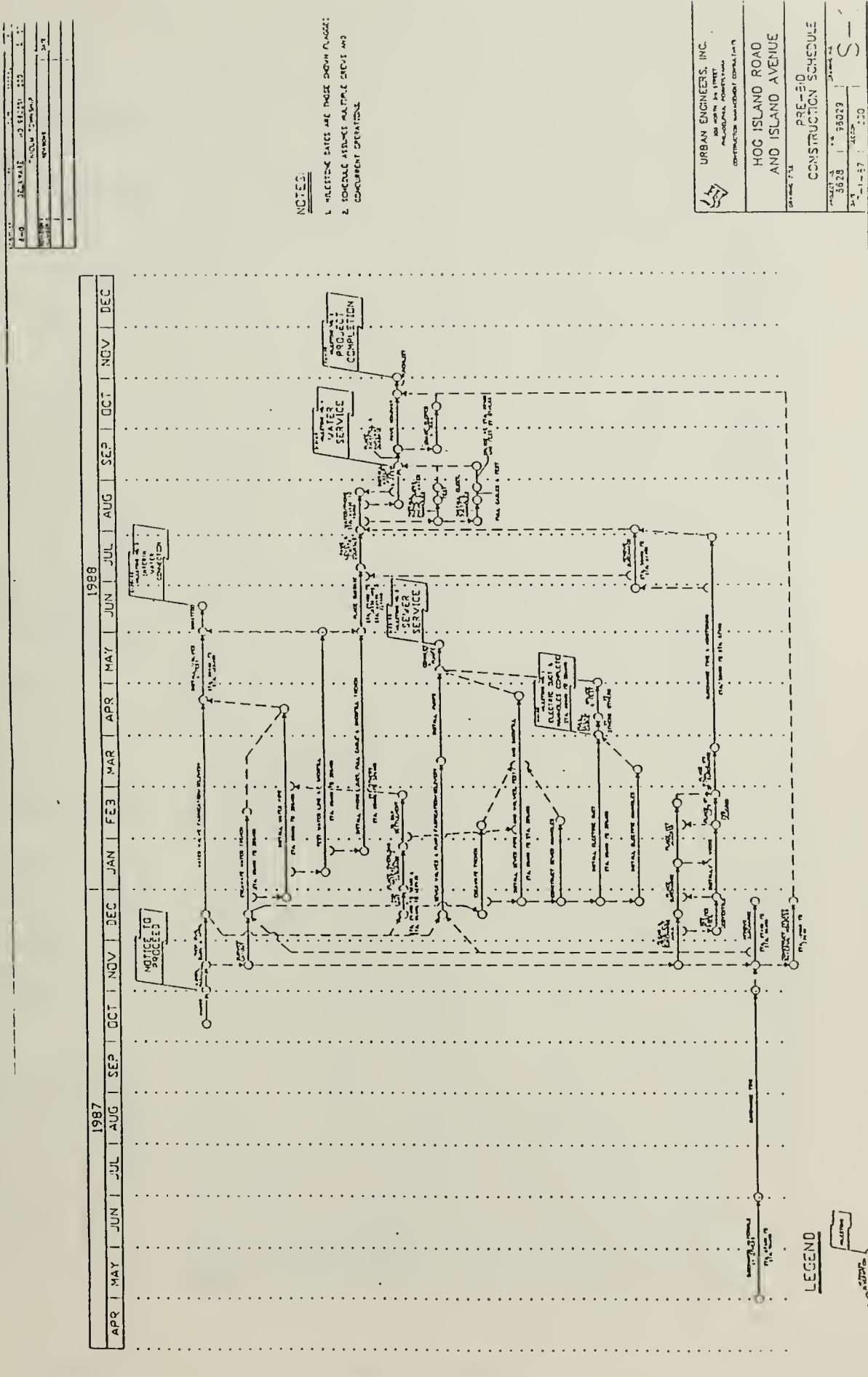


Figure 4.10 Pre-Bid CPM Construction Schedule (Pennsylvania)



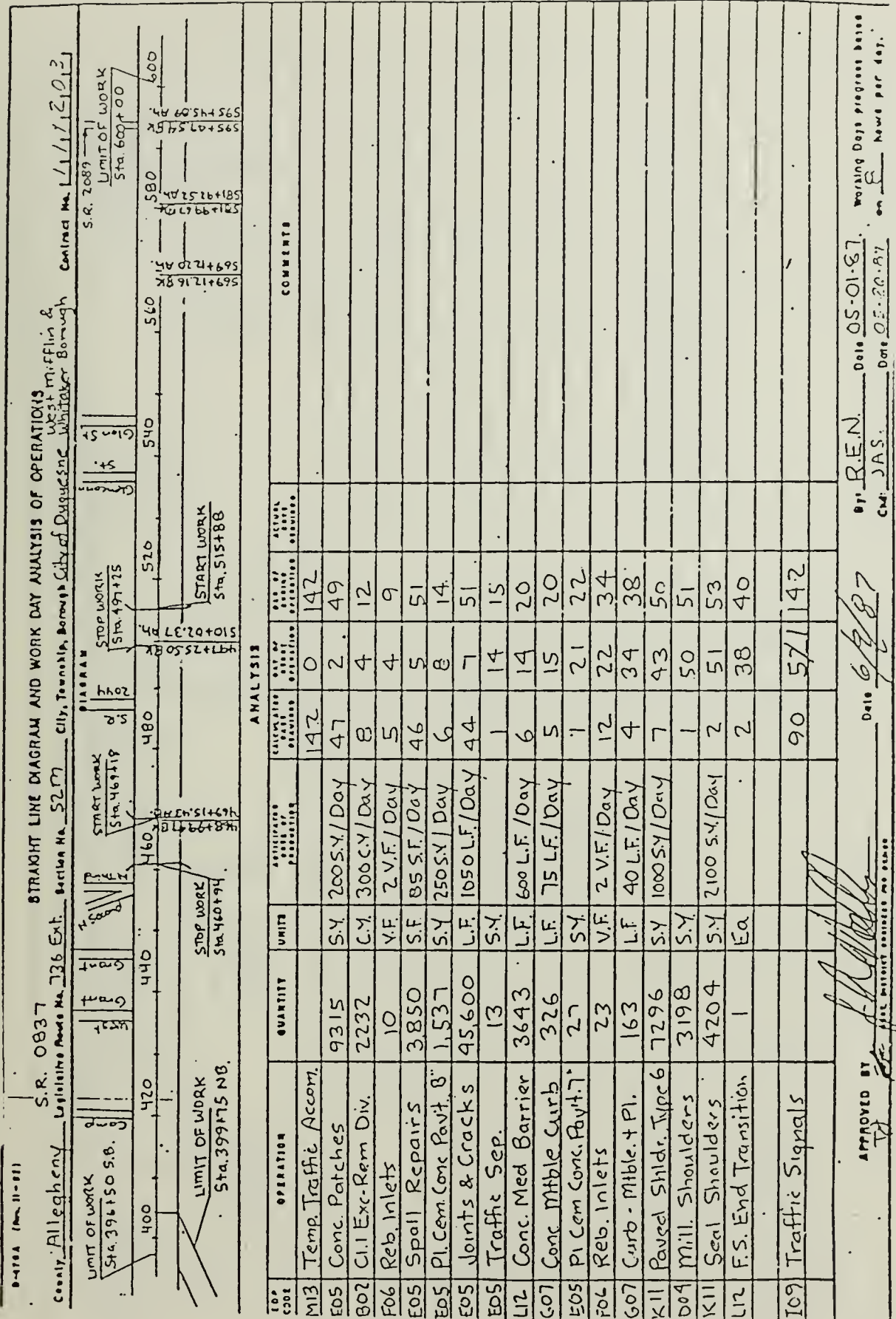


Figure 4.11 Straight-Line Diagram & Analysis of Operations (Pennsylvania)







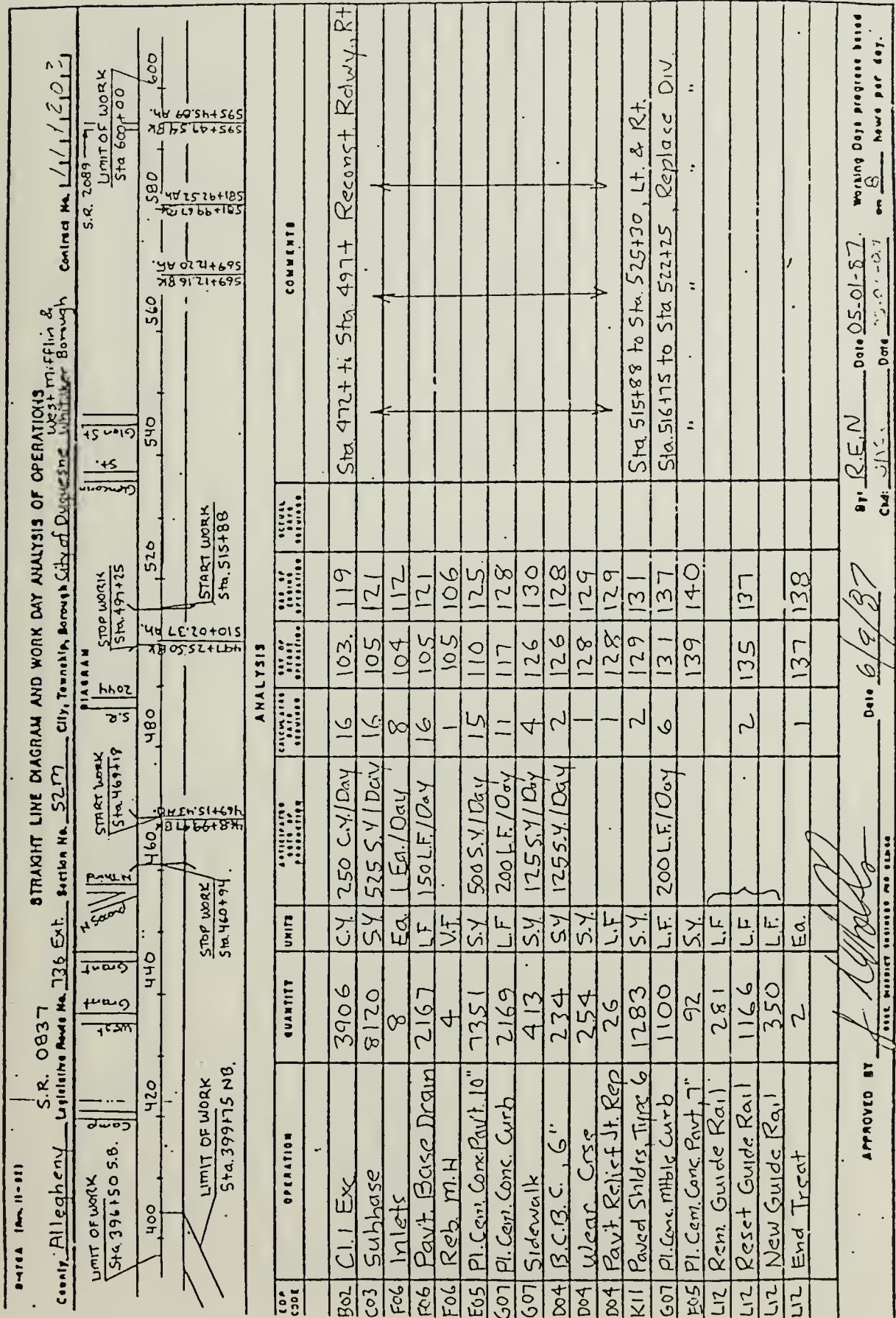
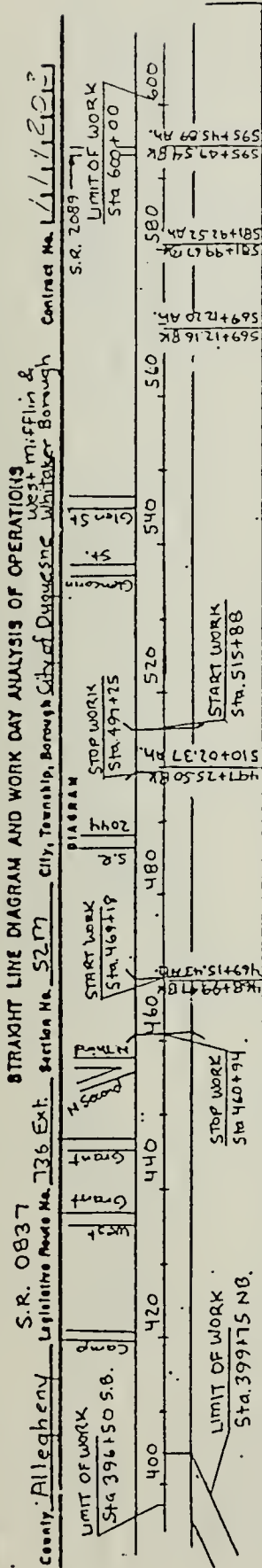


Figure 4.11 (Continued)





| ANALYSIS |                        |          |      |                                |                          |                         |                      |                            |                   |
|----------|------------------------|----------|------|--------------------------------|--------------------------|-------------------------|----------------------|----------------------------|-------------------|
| LINE NO. | OPERATION              | QUANTITY | UNIT | APPROXIMATE RATE OF PRODUCTION | CALCULATED TIME REQUIRED | ESTIMATED TIME REQUIRED | ACTUAL TIME REQUIRED | COMMENTS                   |                   |
| B02      | C11 Exc. Rem Div.      | 105      | CY   |                                | 1                        | 53                      | 54                   | Sta. 516+01 to Sta. 522+25 |                   |
| E05      | Pav't. Repl. Spec.     | 1697     | SY   | 220 S.Y./Day                   | 8                        | 54                      | 62                   |                            | Inside lanes      |
| E05      | P1. Conc. Pav't. 10"   | 245      | SY   |                                | 1                        | 62                      | 63                   |                            | Pave Divisor      |
| H08      | Sel. Tree Rem          | 11       | EA   | 2 Ea./Day                      | 6                        | 62                      | 68                   |                            |                   |
| E05      | Pav't. Repl. Spec.     | 1664     | SY   | 220 S.Y./Day                   | 8                        | 66                      | 74                   | Sta. 516+01 to Sta. 522+25 | Outside lanes     |
| B02      | C11 Exc                | 4033     | CY   | 250 CY/Day                     | 16                       | 77                      | 93                   | Sta. 472+ to Sta. 497+     | Reconst. Rdwy, Lt |
| C03      | Subbase                | 8355     | SY   | 525 S.Y./Day                   | 16                       | 79                      | 95                   |                            |                   |
| F06      | Inlets                 | 9        | EA   | 1 Ea./Day                      | 9                        | 78                      | 87                   |                            |                   |
| F06      | Pav't. Base Drain      | 2427     | L.F. | 150 L.F./Day                   | 16                       | 80                      | 96                   |                            |                   |
| F06      | Reb M.H.               | 20       | V.E  | 4 V.E./Day                     | 5                        | 80                      | 85                   |                            |                   |
| E05      | P1. Conc. Pav't. 10"   | 7532     | SY   | 500 S.Y./Day                   | 15                       | 84                      | 99                   |                            |                   |
| G07      | P1. Conc. Conc. Curb   | 2100     | L.F. | 200 L.F./Day                   | 11                       | 91                      | 102                  |                            |                   |
| G07      | Sidewalks, Ramps       | 1755     | SY   | 125 S.Y./Day                   | 14                       | 93                      | 107                  |                            |                   |
| D04      | Wear Crse.             | 182      | SY   |                                | 1                        | 99                      | 100                  |                            |                   |
| D04      | Pav't. Relief Jt. Rep. | 26       | L.F. |                                | 1                        | 102                     | 103                  |                            |                   |

APPROVED BY *[Signature]* Date 6/9/87 By: R.E.N. Date 05-01-87 Working Days progress based on 8 hours per day.  
 DATE PROJECT COMPLETED AND BILLED Date 11-17-87

Figure 4.11 (Continued)





## DISTRIBUTION OF CONTRACT TIME

CONTRACT NUMBER 1111121031

|                            |                      |                        |   |  |  |  |   |   |   |   |
|----------------------------|----------------------|------------------------|---|--|--|--|---|---|---|---|
| COUNTY<br><u>Allegheny</u> | ROUTE<br><u>0837</u> | SECTION<br><u>5201</u> | CITY - TOWNSHIP - BORO<br><u>City of Duquesne</u> | PREPARED FOR<br>LETTING OF<br><u>July 30, 1987</u> | NOTICE TO PROCEED<br>ANTICIPATED.<br><br>ACTUAL. | 142 WORKING<br>DAYS BASED ON<br>CALENDAR DAYS<br>ALLOWED | Date original schedule<br>reviewed with contractor,<br><br>Did contractor request<br>adjustment of schedule or<br>of contract time? | APPROVED REVISIONS<br>Revision No. _____<br>For Adjustment of Schedule<br>For Adjustment of Contract Time | APPROVED BY<br><u>[Signature]</u><br>PROJECT ENGINEER | FEDERAL PROJECT NUMBER<br><u>6/9/87</u><br>DATE |
|----------------------------|----------------------|------------------------|---|--|--|--|---|---|---|---|

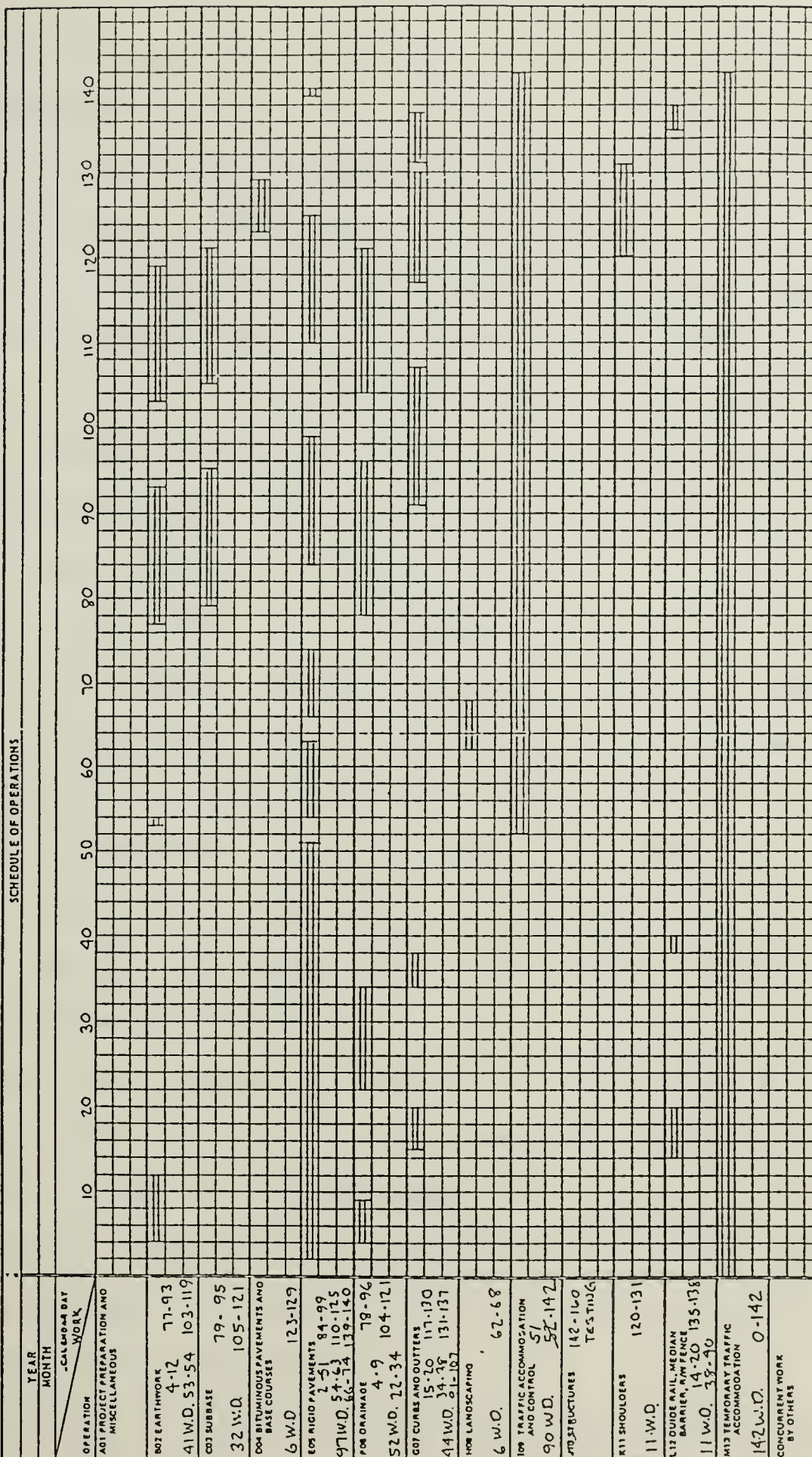


Figure 4.12 Work Day Bar Chart (Pennsylvania)



## SOUTH CAROLINA

The method used to determine contract durations by the South Carolina Department of Highways and Public Transportation is similar to that used in Maryland. Standard productivity rates based on project size and type, and estimated work item quantities determine an unadjusted amount of time needed to complete the work. While Maryland adjusts each individual work item according to "Average Overlap" values, South Carolina adjusts the sum of all controlling work item work days by multiplying the total value by a "concurrency factor" which accounts for the number of potential activities which can be performed simultaneously. This factor can range between 0.5 and 1.0, depending on the type and complexity of the project. The lower end of this range is typical for grading, drainage, paving, and bridge projects, while the upper end of the scale is more suited towards resurfacing projects.

Once the adjusted number of work days has been calculated, the effect of work seasons on contract time is determined. This is accomplished by the use of a "time chart" which accounts for the number of anticipated days per month, depending on type of job, that would be suitable for performing construction work.

Figure 4.13 and 4.14 illustrate this process. As seen in Figure 4.13, the total amount of work days, when adjusted by a concurrency factor of 0.5 applicable to the project





CALCULATION OF CONTRACT TIME

PROJECTS (ESTIMATED COST-OVER \$1,000,000 )

TYP. PRIM. PROJ. (WID., GRAD., DRAIN., C&G., REHAB.) LETTING: JUNE 1987

FILE NO.: 32.806 etc. PROJECT NO.: IR-IRG-20-2(57) COUNTY: RICH/LEX LENGTH: 12.071 MI.

| ITEMS                        | QUANTITY | UNIT | UNITS/DAY          | DAYS |
|------------------------------|----------|------|--------------------|------|
| CLEARING AND GRUBBING        | 12.071   | MILE | 0.3                | 40   |
| UNCLASSIFIED EXCAVATION      | 216676   | CY   | <sup>a)</sup> 3000 | 72   |
| TRAFFIC ITEMS                | 0        | NA   | 1                  | 40   |
| MAC. OR STAB. AGGR. BASE CR. | 2670     | SY   | 1000               | 3    |
| EARTH TYPE BASE COURSE       | 0        | CY   | 800                | 0    |
| SCARIFYING, MIXING, ETC.     | 0        | MSY  | 4                  | 0    |
| MILLING                      | 0        | SY   | 8000               | 0    |
| REM. OF EXIST. PAVT.         | 16296    | SY   | 800                | 20   |
| ASPH. CONC. SURF. CR.        | 56227    | TON  | <sup>a)</sup> 1200 | 47   |
| ASPH. CONC. BIND. CR.        | 91255    | TON  | <sup>a)</sup> 1200 | 76   |
| ASPH. AGGR. BASE CR.         | 135642   | TON  | <sup>a)</sup> 1200 | 113  |
| CONC. CURB & GUTTER          | 18152    | LF   | 300                | 61   |
| CONC. MED. BARRIER           | 39823    | LF   | 1000               | 40   |
| CONC. MEDIAN                 | 2168     | SY   | 150                | 14   |
| PIPE CULVERTS (15"-24")      | 25040    | LF   | 200                | 125  |
| PIPE CULVERTS (30"-54")      | 1672     | LF   | 150                | 11   |
| PIPE CULVERTS (60" OR ))     | 0        | LF   | 100                | 0    |
| CATCH BASINS, MANHOLES, ETC. | 283      | EACH | 8                  | 35   |
| GUARD RAIL                   | 31667    | LF   | 300                | 106  |
| PIPE UNDERDRAINS             | 0        | LF   | 300                | 0    |
| BRICK MASONRY                | 0        | CY   | 25                 | 0    |
| CONC. FOR STRUCTURES         | 353      | CY   | 8                  | 44   |
| FENCE                        | 11600    | LF   | 300                | 39   |
| SEEDING                      | 142      | MSY  | 18                 | 8    |

*Note: Units adjusted for this type of project due to length of haul, location of asphalt plants, etc.*

TOTAL 894

(CONCURRENCEY FACTOR = 0.5) ADJUSTED TOTAL (DAYS) 447

COMPLETION DATE : JUNE 30, 1990 - OK - *[Signature]*

Figure 4.13 Calculation of Contract Time Sheet (South Carolina)



GRADING, DRAINAGE, BASE & SURFACING PROJECTS

| LETTING DATE |                    |         |          |       |       |     |      |      |        |           |         |          |          |
|--------------|--------------------|---------|----------|-------|-------|-----|------|------|--------|-----------|---------|----------|----------|
| Month        | Working Days/Month | January | February | March | April | May | June | July | August | September | October | November | December |
| January      | 5                  | 311     | 297      | 278   | 260   | 239 | 219  | 201  | 184    | 173       | 168     | 163      | 157      |
| February     | 6                  | 317     | 303      | 284   | 266   | 245 | 225  | 207  | 190    | 179       | 174     | 169      | 163      |
| March        | 9                  | 326     | 312      | 293   | 275   | 254 | 234  | 216  | 199    | 188       | 183     | 178      | 172      |
| April        | 14                 | 14      | 326      | 307   | 289   | 268 | 248  | 230  | 213    | 202       | 197     | 192      | 186      |
| May          | 19                 | 33      | 19       | 326   | 308   | 287 | 267  | 249  | 232    | 221       | 216     | 211      | 205      |
| June         | 18                 | 51      | 37       | 18    | 326   | 305 | 285  | 267  | 250    | 239       | 234     | 229      | 223      |
| July         | 21                 | 72      | 58       | 39    | 21    | 326 | 306  | 288  | 271    | 260       | 255     | 250      | 244      |
| August       | 20                 | 92      | 78       | 59    | 41    | 20  | 326  | 308  | 291    | 280       | 275     | 270      | 264      |
| September    | 18                 | 110     | 96       | 77    | 59    | 38  | 18   | 326  | 309    | 298       | 293     | 288      | 282      |
| October      | 17                 | 127     | 113      | 94    | 76    | 55  | 35   | 17   | 326    | 315       | 310     | 305      | 299      |
| November     | 11                 | 138     | 124      | 105   | 87    | 66  | 46   | 28   | 11     | 326       | 321     | 316      | 310      |
| December     | 5                  | 143     | 129      | 110   | 92    | 71  | 51   | 33   | 16     | 5         | 326     | 321      | 315      |
| January      | 5                  | 148     | 134      | 115   | 97    | 76  | 56   | 38   | 21     | 10        | 5       | 326      | 320      |
| February     | 6                  | 154     | 140      | 121   | 103   | 82  | 62   | 44   | 27     | 16        | 7       | 6        | 326      |
| March        | 9                  | 163     | 149      | 130   | 112   | 91  | 71   | 53   | 36     | 25        | 20      | 15       | 9        |
| April        | 14                 | 177     | 163      | 144   | 126   | 105 | 85   | 67   | 50     | 39        | 34      | 29       | 23       |
| May          | 19                 | 196     | 182      | 163   | 145   | 124 | 104  | 86   | 69     | 58        | 53      | 48       | 42       |
| June         | 18                 | 214     | 200      | 181   | 163   | 142 | 122  | 104  | 87     | 76        | 71      | 66       | 60       |
| July         | 21                 | 235     | 221      | 202   | 184   | 163 | 143  | 125  | 108    | 97        | 92      | 87       | 81       |
| August       | 20                 | 255     | 241      | 222   | 204   | 183 | 163  | 145  | 128    | 117       | 112     | 107      | 101      |
| September    | 18                 | 273     | 259      | 240   | 222   | 201 | 181  | 163  | 146    | 135       | 130     | 125      | 119      |
| October      | 17                 | 290     | 276      | 257   | 239   | 218 | 198  | 180  | 163    | 152       | 147     | 142      | 136      |
| November     | 11                 | 301     | 287      | 268   | 250   | 229 | 209  | 191  | 174    | 163       | 158     | 153      | 147      |
| December     | 5                  | 306     | 292      | 273   | 255   | 234 | 214  | 196  | 179    | 168       | 163     | 158      | 152      |

File No. 32.806 etc. - Roadway items were determining factor.

- (1) Allowed two months for scheduling and mobilization: Began counting time in September 1987.
- (2) 447 days required. -  $326 + 122 = 448$  - Set C.D. - June 30, 1990

Figure 4.14 Grading, Drainage, Base, and Surfacing Project Time Chart (South Carolina)



shown, equals 447 work days. Considering a contract letting in June, 1987, and 163 work days/year as determined by the time chart of Figure 4.14, work through the full month of June, 1990 is necessary for this particular project.

To show the effect on the number of anticipated work days per month by the type of job involved, a time chart for resurfacing projects is shown in Figure 4.15. As can be seen, these values differ significantly from those of Figure 4.14, and the total number of anticipated work days per year is calculated as 147 vice 163.

#### WYOMING

The Critical Path Method is used by the Wyoming Highway Department in determining contract durations. The procedures followed were summarized by the Transportation Research Board in their Synthesis of Highway Practice, Special Report 79 entitled "Contract Time Determination" and are included as Appendix E.





# RESURFACING PROJECTS

| Month     | Working Days/Month | LETTING DATE |          |       |       |     |      |      |        |           |         |          |          |
|-----------|--------------------|--------------|----------|-------|-------|-----|------|------|--------|-----------|---------|----------|----------|
|           |                    | January      | February | March | April | May | June | July | August | September | October | November | December |
| January   | 0                  | 285          | 271      | 252   | 234   | 213 | 193  | 175  | 158    | 147       | 147     | 147      | 147      |
| February  | 0                  | 285          | 271      | 252   | 234   | 213 | 193  | 175  | 158    | 147       | 147     | 147      | 147      |
| March     | 9                  | 294          | 280      | 261   | 243   | 222 | 202  | 184  | 167    | 156       | 156     | 156      | 156      |
| April     | 14                 | 14           | 294      | 275   | 257   | 236 | 216  | 198  | 181    | 170       | 170     | 170      | 170      |
| May       | 19                 | 33           | 19       | 294   | 276   | 255 | 235  | 217  | 200    | 189       | 189     | 189      | 189      |
| June      | 18                 | 51           | 37       | 18    | 294   | 273 | 253  | 235  | 218    | 207       | 207     | 207      | 207      |
| July      | 21                 | 72           | 58       | 39    | 21    | 294 | 274  | 256  | 239    | 228       | 228     | 228      | 228      |
| August    | 20                 | 92           | 78       | 59    | 41    | 20  | 294  | 276  | 259    | 243       | 248     | 248      | 248      |
| September | 18                 | 110          | 96       | 77    | 59    | 38  | 18   | 294  | 277    | 266       | 266     | 266      | 266      |
| October   | 17                 | 127          | 113      | 94    | 76    | 55  | 35   | 17   | 294    | 283       | 283     | 283      | 283      |
| November  | 11                 | 138          | 124      | 105   | 87    | 66  | 46   | 28   | 11     | 294       | 294     | 294      | 294      |
| December  | 0                  | 138          | 124      | 105   | 87    | 66  | 46   | 28   | 11     | 0         | 294     | 294      | 294      |
| January   | 0                  | 138          | 124      | 105   | 87    | 66  | 46   | 28   | 11     | 0         | 0       | 294      | 294      |
| February  | 0                  | 138          | 124      | 105   | 87    | 66  | 46   | 28   | 11     | 0         | 0       | 0        | 294      |
| March     | 9                  | 147          | 133      | 114   | 96    | 75  | 55   | 37   | 20     | 9         | 9       | 9        | 9        |
| April     | 14                 | 161          | 147      | 128   | 110   | 89  | 69   | 51   | 34     | 23        | 23      | 23       | 23       |
| May       | 19                 | 180          | 166      | 147   | 129   | 108 | 88   | 70   | 53     | 42        | 42      | 42       | 42       |
| June      | 18                 | 198          | 184      | 165   | 147   | 126 | 106  | 88   | 71     | 60        | 60      | 60       | 60       |
| July      | 21                 | 219          | 205      | 186   | 168   | 147 | 127  | 109  | 92     | 81        | 81      | 81       | 81       |
| August    | 20                 | 239          | 225      | 206   | 188   | 167 | 147  | 129  | 112    | 101       | 101     | 101      | 101      |
| September | 18                 | 257          | 243      | 224   | 206   | 185 | 165  | 147  | 130    | 119       | 119     | 119      | 119      |
| October   | 17                 | 274          | 260      | 241   | 223   | 202 | 182  | 164  | 147    | 136       | 136     | 136      | 136      |
| November  | 11                 | 285          | 271      | 252   | 234   | 213 | 193  | 175  | 158    | 147       | 147     | 147      | 147      |
| December  | 0                  | 285          | 271      | 252   | 234   | 213 | 193  | 175  | 158    | 147       | 147     | 147      | 147      |

Charts allow couple of months for scheduling and mobilization.

Figure 4.15 Resurfacing Project Time Chart (South Carolina)





## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### A. Conclusions.

As outlined in this report, there are various methods used by state transportation agencies for setting time limits on construction projects. Most commonly, the basis for determining contract time includes reliance on construction seasons, anticipated production rates, work-flow techniques, and estimated project cost. In most cases, a combination of two or more of these methods is used in contract time determination, depending on the size, type, and urgency of the work involved.

Probably one of the most important factors in the determination of reasonable contract durations is the performance evaluation of existing methods being used. While most agencies stated that their procedures were based on historical data, only the Maine Department of Transportation provided documentation (although "sketchy") in their survey response that showed the monitoring of estimated work days versus actual work days, and estimated productivity values versus actual productivity values (see Figures 5.1 and 5.2).



| Town                                    | Project No. | Total Cost | Working Days |          | Liq. Dam. | Production Notes |               |
|---|-------------|------------|--------------|----------|-----------|------------------|---------------|
|   |             |            | Allowed      | Adjusted | Changed   | Under            | Over          |
|   |             |            |              |          |           | Days Est         | Worked Actual |
| Harmeny- <del>Cambridge</del>           |             |            | 125          |          | 116       |                  |               |
| 0241(18)                                | 7489100     |            |              |          |           | 130              | 135           |
| Fairfield-Norridgewick                  |             |            | 110          |          | 109       |                  |               |
| 045-1(7)                                | 936000      |            |              |          |           | 112              | 96            |
| Wauke                                   |             |            | 65           |          | 64        |                  |               |
| 013-1(2)                                | 292800      |            |              |          |           | 65               | 61            |
| China                                   |             |            | 60           |          | 58        |                  |               |
| 028-1(23) & 0210(30)                    | 412000      |            |              |          |           | 60               | 44            |
| Belgrade-Oakland                        |             |            | 15           |          | 19        |                  |               |
| 0228(2)                                 | 295000      |            |              |          |           | 15               | 19            |
| Winslow                                 |             |            | 40           |          | 42        |                  |               |
| M-7503(3)                               | 275000      |            |              |          |           | 40               | 40            |
| Crowford                                |             |            | 85           |          | 66        |                  |               |
| 046-1(26)                               | 647800      |            |              |          |           | 85               | 72            |
| Wells                                   |             |            | 40           |          | 47        |                  |               |
| 06-1(15) & 07-1(6)                      | 281500      |            |              |          |           | 40               | 36            |
| Chelsea                                 |             |            | 25           |          | 26        |                  |               |
| 0204(2)                                 |             |            |              |          |           | 22               | 21            |
| Mt Desert                               |             |            | 45           |          | 46        |                  |               |
| 0257(14)                                | 294600      |            |              |          |           | 45               | 59            |
| Gardiner                                |             |            | 65           |          | 31        |                  |               |
| RS-0165(5)                              | 131600      |            |              |          |           | 65               | 27            |
| Albany to Belfast                       |             |            | 45           |          | 45        |                  |               |
| 0210(10) & 0176(6) & 0177(18) & 0171(1) | 929900      |            |              |          |           | 45               | 40            |
| Ashburn                                 |             |            | 50           |          | 47        |                  |               |
| 0224(1)                                 | 361000      |            |              |          |           | 70               | 68            |
| Perry-Kobbin-stony                      |             |            | 90           |          | 42        |                  |               |
| 044-2(24)                               | 1,147,000   |            |              |          |           | 115              | 121           |
| to my                                   |             |            |              |          |           |                  |               |
| 044-2(23)                               |             |            |              |          |           |                  |               |
| Crowford                                |             |            | 75           |          | 57        |                  |               |
| 046-1(31)                               | 464500      |            |              |          |           | 75               | 53            |
| Litchton-Monkton                        |             |            | 115          |          | 101       |                  |               |
| 050-3(28)                               | 1485100     |            |              |          |           | 113              | 145           |
| Scarborough                             |             |            | 90           |          | 99        |                  |               |
| M-0527(1)                               | 422600      |            |              |          |           | 90               | 104           |
| Mt Desert                               |             |            | 55           |          | 46        |                  |               |
| 0257(116)                               | 239000      |            |              |          |           | 55               | 43            |
| Mile - Monmouth                         |             |            | 80           |          | 79        |                  |               |
| 50-1(40) & 6                            | 1530700     |            |              |          |           | 80               | 60            |
| Hannock                                 |             |            | 75           |          | 75        |                  |               |
| 0221-1(29)                              | 749000      |            |              |          |           | 100              | 115           |
| Caswell                                 |             |            | 120          |          | 127       |                  |               |
| 0332(22)                                | 1353300     |            |              |          |           | 116              | 125           |
| Greene-Monmouth                         |             |            | 70           |          | 77        |                  |               |
| 015-1(44)                               | 722500      |            |              |          |           | 70               | 73            |
| Hannock-Ottisfield                      |             |            | 115          |          | 162       |                  |               |
| 019-1(11)                               | 775000      |            |              |          |           | 148              | 250           |
| Eagle Lake                              |             |            | 150          |          | 135       |                  |               |
| 0340(25)                                | 1584000     |            |              |          |           | 150              | 133           |
| Kennebunk Park                          |             |            | 65           |          | 84        |                  |               |
| 0112(11)                                | 582800      |            |              |          |           | 75               | 120           |
| Scarboro                                |             |            |              |          |           |                  |               |
| 01-1(68) & 59                           | 879000      |            |              |          |           | 80               | 142           |

Figure 5.1 Estimated-vs-Actual Work Days (Maine)



PRODUCTIONS  
FAP Highway

5-10

| Item                  | Hot Top D |      | Hot Top B        |      | Hot Top C |      | HT Misc |      |
|-----------------------|-----------|------|------------------|------|-----------|------|---------|------|
| Town                  | Actual    | Est. | Actual           | Est. | Actual    | Est. | Actual  | Est. |
| Chelsea               | 530       | 683  |                  |      |           |      | 17      | 33   |
| Mt. Desert            |           |      | →                |      | 290       | 285  |         |      |
| Gardiner              |           |      | 130              | 225  | 268       | 230  |         |      |
| Fryeburg              |           |      | →                |      | 396       | 196  |         |      |
| Albany to Belfast     | 1282      | 1146 | 1                |      |           |      | 25      | 52   |
| Auburn                |           |      | 277              | 404  | 368       | 395  | 49      | 50   |
| Perry-Robbinston      | 532       | 550  |                  |      | 589       | 563  | 20      | -    |
| Perry                 | 416       | 550  |                  |      | 463       | 540  | 15      | 40   |
| Grafton               |           |      | 612              | 525  | 406       | 488  |         |      |
| Littleton-Masticella  | 461       | 760  | 298 Base         | 475  | 327       | 760  | 93      | 57   |
| " "                   |           |      | 686 "B"          | 777  |           |      |         |      |
| Scarborough           |           |      | 410              | 315  | 450       | 277  | 39      | 45   |
| Mt. Desert            |           |      | 311              | 207  | 341       | 250  |         |      |
| Milo - Enfield        | 1195      | 1114 |                  |      |           |      |         |      |
| Lisecy - Macwahoc     | 1621      | 1089 |                  |      |           |      | 53      | 50   |
| Jockman - Moose River | 249       | 390  |                  |      |           |      |         |      |
| Harsco                |           |      | 382              | 593  | 409       | 700  | 57      | 60   |
| Casswell              |           |      | 675              | 521  | 537       | 275  | 51      | 67   |
| Greene - Highland     | 456       | 761  | 360              | 237  | 510       | 778  | 32      | 33   |
| Harrison - Othfield   |           |      | 520              | 528  | 485       | 450  |         |      |
| Eagle Lake            |           |      | 835.524<br>B 488 | 463  | 514       | 443  | 55      | 100  |
| Kennebunkport         |           |      | 729              | 421  | 452       | 550  | 39      | 55   |
| Scarboro              | 344       | 360  | 316              | 526  | 547       | 487  | 63      | 40   |

Figure 5.2 Estimated-vs-Actual Productivity Rates (Maine)





To determine the validity of existing procedures, it is essential that careful observance be made on all jobs, whether they are completed early, late, or on time, with diary notes kept on determining conditions of each.

To best make use of historical data, an agency should maintain a construction data file that contains such items as production rates, time, weather effects, effects of various job conditions, etc. that cover the previous 3 to 5 year period. Factors discussed earlier in this report including construction season effects, agency cash flow, availability of potential contractors and/or materials, related utility work, and agency commitments should also be given due consideration before final determination of contract time is made. In many cases, standard productivity rates included with agency survey responses were not the same rates used in representative project time determination worksheets provided by the same state agency. As previously discussed, revising figures to accommodate the unique conditions of each particular project is important, but when doing so, it is just as important to document reasons for revisions for future evaluation.

The objective of the agency is the satisfactory and timely completion of work; not the collection of liquidated damages<sup>27</sup>. To this end, it is the agency's responsibility to ensure that contract times are reasonable. Contracts that contain more time than is necessary to complete the work, as





well as contracts that do not allow adequate time for project completion, may result in a poorer quality job, or an increased cost of construction.

Even with utmost care and consideration given to the determination of contract durations, problems may still occur. Factors may be overlooked during the planning stages of a project, contractors may bid more work than they can handle, union difficulties may arise, or site conditions may vary from those thought to exist at the time of contract time determination. It is this point in time that an agency's scheduling efforts in determining contract time becomes extremely valuable. Schedules developed by an agency can be very useful for monitoring work progress, and aid in determining whether steps must be taken to get the contractor back on schedule. They also help substantiate liquidated damages that may be assessed against a contractor, or refute unjustified contractor claims for time extensions.

#### B. General Recommendations.

The Transportation Research Board has suggested the following general guidelines for state agencies when computing contract durations<sup>28</sup>:

1. It is recommended that agencies be flexible in establishing project working days or completion dates. It is not desirable to be highly restrictive in specifying contract duration. For some projects, selecting contract time based



on construction seasons appears to have merit. Liberal use of construction-season time limits on paving and resurfacing projects will help contractors in keeping bids reasonable.

2. When a contract must be completed within a narrow range of time, specifying a contract completion date is preferable to the stipulation of the number of working or calendar days.

3. Once specified, contract time becomes a contractual condition and should be rigorously enforced.

4. Liquidated damages should be prescribed according to the time that traffic and/or the general public is inconvenienced, and for direct engineering supervision costs of minor completion off the roadway.

5. The time required to complete a construction project may be based on past experience with similar work. It is recommended that a formal rational approach be developed for use in determining time requirements.

6. Some means of showing the time available for specific items of project work is recommended. A precedence (CPM) chart or bar chart may be prepared manually or with the aid of a computer.

7. Time schedules should be compared with the actual progress on the project. The contractor should be required to prepare a revised schedule if a work slowdown occurs.



8. Enforcement of time charges on working-day contracts should be administered uniformly and fairly. The contractor should be given the opportunity to contest time charges.

9. Production rates and other variables used to estimate contract time should be updated monthly or after each major letting. Data not reflecting current conditions should be removed from the file.

10. In setting contract time limits, a decision must be made on whether to have the construction project completed by a specific date at any cost or to have the project completed in a reasonable period of time at reasonable cost. The agency should be responsible for identifying the projects that must be completed at the earliest practical date. The agency must also decide whether to use only liquidated damages or to specify incentive payments in addition to liquidated damages.

11. Each method of setting contract time should be evaluated by comparing contract completion times to actual completion times. An analysis of the frequency of the use of liquidated damages and bonuses should be made when modifications of the methods are considered.

Another recommendation is that the states make an attempt to establish common terminology for work categories so that comparisons can be made, at least within geographical regions, to assist in the evaluation and updating of currently used productivity rates and other job factors.





### C. Proposed Methodology for Determining Contract Time.

In the vast majority of cases it is not necessary for agencies to determine exact day-to-day schedules for projects when establishing contract time, it is only necessary to consider those work items that are significant or controlling in nature. For this reason, with the exception of large, complex projects, simple bar charts are more than adequate when determining reasonable contract durations. They are easy to understand and prepare. The following step-by-step approach, nearly identical to the approach outlined in the June, 1981 ASCE paper "Setting Highway Construction Contract Duration" by Donn E. Hancher, and James E. Rowings, is offered as a suggested method of determining contract time, using the work items and dependencies of the Indiana bridge project shown in Figure 3.14.

Step 1. The first step in determining the amount of time necessary for completing a particular project is to examine all project drawings, specifications, and contract documents. In order to determine all of the necessary work activities which must be completed on the project, the person establishing the contract duration must become familiar with the existing conditions, the scope of work, and any special requirements or procedures which are incorporated in the contract. This step will help determine the type of





contractor that is expected to bid the job, thereby indicating the range of anticipated productivity rates for the project.

Step 2. Once there is a full understanding of all project requirements, significant and controlling work activities must be identified. These activities should be numbered and listed as close to chronological order as possible on a worksheet such as that shown in Figure 5.3. The corresponding quantities for each bid item or work activity should be listed in the third column of this worksheet. Consideration should be given to significant material procurement periods, as well as time periods necessary for such things as shop drawing submittals/approvals, or concrete curing.

Step 3. After all salient work activities have been identified and listed, the project logic must be established. This involves the identification of those activities that must precede the activity in question. These dependencies should be listed in the sixth column of Figure 5.3.

Not all logic is based on starting an activity immediately following the completion of a preceding activity; there are a few varying relationships that may occur, such as minimum or maximum time periods specified between start-to-start, start-to-finish, or finish-to-finish activity times. The variation that is most common, and of most importance to



## CONTRACT TIME DETERMINATION WORKSHEET

[illegible]

Figure 5.3 Contract Time Determination Worksheet



the individual determining contract time, is the start-to-start relationship. This case has many occurrences in construction. For example, in a new road construction project, paving may begin if it is started a certain distance (or time period) behind roadway preparation operations, or forms may be stripped from concrete slabs a certain number of days after the concrete is poured but before it has finished curing. This relationship can be indicated on the worksheet by showing the number of days between activity start times in work days placed in parentheses after the activity listed in column 6. An advantage to this step is that it helps to identify work activities that may have been omitted from the original work item list, work items that need further breakdown to support the logic, and work items that may be grouped together without confusing the project logic.

Step 4. The next step is the establishment of activity durations. This is accomplished through the use of anticipated productivity rates for each of the work activities. As discussed earlier in this report, average productivity rates should be based on historical data of the past 3 to 5 years, and reviewed and updated periodically to ensure reliability. Once the productivity rates are known for each of the work activities, they should be entered into the fourth column of Figure 5.3. Activity durations, located in column 5, are calculated by dividing the work item quantity in column 3 by the the daily productivity rate in





column 4. The resulting value, which should be rounded up to the nearest whole number, is the number of working days an individual work item requires for completion.

Step 5. With the project logic established, start and finish times for each activity may be determined. The assumption is made that the project starts on work day 0, and all activities that have no preceding activities which are depended upon have a start time of 0. This should be entered in column 7 of Figure 5.3. Finish times for these activities then are simply their durations, which are listed in column 5. Finish times should be placed in column 8. Next, the activities that have dependency relationships are considered. For each of the activities, a comparison must be made of the finish times of all preceding work items that the activity is dependent upon. The largest value of these becomes the start time and is entered in column 7. The finish time is then calculated by adding the activity duration to the start time. When considering activities that have start-to-start relationships, the number in the parentheses should be added to the start time of the preceding activity and compared with the finish times of any other preceding activities. This procedure is continued until start and finish times for all activities has been determined. The largest of the finish time values in column 8 is the contract time in work days. Any special considerations for contingencies may be added at this time.





Completion of steps one through five is all that is necessary in determining contract time for working day contracts. Figure 5.4 illustrates the manner in which these steps are taken and documented. As shown, not including any contingencies, contract time for this particular project is 90 working days.

If it is desired to express the contract time in calendar days, or as a calendar date, a work-day-calendar conversion chart based on location and project type should be used, similar to those used by South Carolina, as shown in Figures 4.14 and 4.15.

Step 6. To make full use of the information that has been tabulated up to this point, a time-scaled bar chart should be drawn. As discussed earlier in this report, this is a valuable tool that assists in the visualization of the construction logic and the monitoring of construction progress. Figure 3.14 shows such a chart for the values found in Figure 5.4. A calendar day bar chart could just as easily be completed with consideration given to non-working weekends and holidays. When considering non-work day periods, activity durations for such items as concrete curing would have to be adjusted to account for curing during these time-frames.

There are numerous computer software programs on the market that have the capability of performing the steps described above, and much more. With only minimal effort,



# CONTRACT TIME DETERMINATION WORKSHEET

| (1)<br>No. | (2)<br>Work Item                     | (3)<br>Quantity | (4)<br>Daily<br>Productivity | (5)<br>Dur. | (6)<br>Act.<br>Depend. | (7)<br>Start<br>Time | (8)<br>Finish<br>Time |
|------------|--------------------------------------|-----------------|------------------------------|-------------|------------------------|----------------------|-----------------------|
| 1          | Move-In                              | --              | --                           | 5           | --                     | 0                    | 5                     |
| 2          | Remove Existing<br>Structure         | --              | --                           | 5           | 1                      | 5                    | 10                    |
| 3          | Order & Deliver<br>Piling            | --              | 21                           | --          | --                     | 0                    | 21                    |
| 4          | Construct Fill                       | 8,000cy         | 500cy/day                    | 16          | 2                      | 10                   | 26                    |
| 5          | Bent 1<br>Cofferdam                  | 1 ea.           | --                           | 3           | 4                      | 26                   | 29                    |
| 6          | Bent 1 Piling                        | 1,500lf         | 500lf/day                    | 3           | 3,5                    | 29                   | 32                    |
| 7          | Bent 1 Form &<br>Place Footing       | 10cy            | 10cy/day                     | 1           | 6                      | 32                   | 33                    |
| 8          | Bent 1 Cure<br>Footing               | --              | --                           | 1           | 7                      | 33                   | 34                    |
| 9          | Dewater, Form &<br>Place Bent 1 Stem | 20cy            | 10cy/day                     | 2           | 8                      | 34                   | 36                    |
| 10         | Bent 1 Cap                           | 10cy            | 10cy/day                     | 2           | 9                      | 36                   | 38                    |
| 11         | Bent 2 Cofferdam                     | 1 ea.           | --                           | 3           | 5                      | 29                   | 32                    |
| 12         | Bent 2 Piling                        | 1500lf          | 500lf/day                    | 3           | 6,11                   | 32                   | 35                    |
| 13         | Bent 2 Form &<br>Place Footing       | 10cy            | 10cy/day                     | 1           | 7,9,12                 | 36                   | 37                    |
| 14         | Bent 2 Cure Ftg.                     | --              | --                           | 1           | 13                     | 37                   | 38                    |
| 15         | Dewater, Form &<br>Place Bent 2 Stem | 20cy            | 10cy/day                     | 2           | 9,14                   | 38                   | 40                    |
| 16         | Bent 2 Cap                           | 10cy            | 10cy/day                     | 2           | 15                     | 40                   | 42                    |
| 17         | North End Bent<br>Drive Piling       | 1000lf          | 500lf/day                    | 2           | 12                     | 35                   | 37                    |

FIGURE 5.4 Contract Time Determination Worksheet  
(Indiana Bridge Project)



# CONTRACT TIME DETERMINATION WORKSHEET

| (1)<br>No. | (2)<br>Work Item                     | (3)<br>Quantity | (4)<br>Daily<br>Productivity | (5)<br>Dur. | (6)<br>Act.<br>Depend. | (7)<br>Start<br>Time | (8)<br>Finish<br>Time |
|------------|--------------------------------------|-----------------|------------------------------|-------------|------------------------|----------------------|-----------------------|
| 18         | North End Bent<br>Form & Place       | 30cy            | 10cy/day                     | 3           | 15,17                  | 40                   | 43                    |
| 19         | N. End Bent Cure                     | --              | --                           | 4           | 18                     | 43                   | 47                    |
| 20         | South End Bent<br>Drive Piling       | 1000lf          | 500lf/day                    | 2           | 17                     | 37                   | 39                    |
| 21         | South End Bent<br>Form & Place       | 30cy            | 10cy/day                     | 3           | 18,20                  | 43                   | 46                    |
| 22         | S. End Bent Cure                     | --              | --                           | 4           | 21                     | 46                   | 50                    |
| 23         | Order/Dlvr Beams                     | --              | --                           | 45          | --                     | 0                    | 45                    |
| 24         | Set Beams                            | --              | --                           | 2           | 10,16,<br>19,22,<br>23 | 50                   | 52                    |
| 25         | Form & Place<br>Diaphragms           | 15cy            | 5cy/day                      | 3           | 24                     | 52                   | 55                    |
| 26         | Cure Diaphragms                      | --              | --                           | 4           | 25                     | 55                   | 59                    |
| 27         | Form Deck&Coping                     | --              | --                           | 4           | 26(1)                  | 56                   | 60                    |
| 28         | Rebar                                | 60,000lbs       | 20,000lb/day                 | 3           | 27(2)                  | 58                   | 61                    |
| 29         | Place Deck W/O<br>Support Cuttouts   | 150cy           | 150cy/day                    | 1           | 28                     | 61                   | 62                    |
| 30         | Remove Bulkheads<br>& Place Concrete | 20 cy           | 10cy/day                     | 2           | 29                     | 62                   | 64                    |
| 31         | Cure Deck                            | --              | --                           | 4           | 30                     | 64                   | 68                    |
| 32         | Form & Place<br>Top Wall             | 3cy             | 15cy/day                     | 2           | 31(3)                  | 67                   | 69                    |
| 33         | Cure Top Wall                        | --              | --                           | 4           | 32                     | 69                   | 73                    |
| 34         | Reinforced Conc.<br>Approaches       | 180cy           | 30cy/day                     | 6           | 32                     | 69                   | 75                    |

FIGURE 5.4 (Continued)





# CONTRACT TIME DETERMINATION WORKSHEET

| (1)<br>No. | (2)<br>Work Item          | (3)<br>Quantity | (4)<br>Daily<br>Productivity | (5)<br>Dur. | (6)<br>Act.<br>Depend. | (7)<br>Start<br>Time | (8)<br>Finish<br>Time |
|------------|---------------------------|-----------------|------------------------------|-------------|------------------------|----------------------|-----------------------|
| 35         | Cure Approaches           | --              | --                           | 4           | 34                     | 75                   | 79                    |
| 36         | Place Compacted Aggregate | 450tons         | 2000tons/day                 | 1           | 34                     | 75                   | 76                    |
| 37         | Place Bituminous Mix      | 250tons         | 1300tons/day                 | 1           | 36                     | 76                   | 77                    |
| 38         | Bridge Rail               | 800lf           | 600lf/day                    | 2           | 33, 35,<br>37          | 79                   | 81                    |
| 39         | Guard Rail                | 1200lf          | 600lf/day                    | 2           | 37                     | 77                   | 79                    |
| 40         | Seeding&Sodding           | 5000sy          | 2500sy/day                   | 2           | 37                     | 77                   | 79                    |
| 41         | Clean Up                  | --              | --                           | 9           | 38, 39<br>40           | 81                   | 90                    |

FIGURE 5.4 (Continued)





the use of such programs can be mastered by state agency personnel, resulting in much less time and effort necessary in determining reasonable contract durations.



APPENDIX A  
STANDARD PRODUCTION RATES FOR ESTIMATING WORK DAYS



TABLE A-1.a - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *       | * ARKANSAS *          | * FLORIDA *        | * LOUISIANA *           | * MARYLAND *            |
|---------------------|-----------------------|--------------------|-------------------------|-------------------------|
| *Move-In            | 5 days                | 15-25 days (a)     |                         | 10 days                 |
| *Clean up           | 5 days                |                    |                         | 10 days                 |
| *Clear & Grub       | 5 sta./day (b)        | 1-10 acres/day     | 1.5 acres/day           |                         |
|                     | 10 sta./day (c)       |                    |                         |                         |
| *Seeding            |                       | 15000 sy/day (e)   |                         |                         |
| *Sodding            |                       |                    |                         |                         |
| *Fence              |                       |                    | 500-1000 lf/day         |                         |
|                     |                       |                    |                         |                         |
| *Curb & Gutter      |                       | 300-700 lf/day     | 700 lf/day              |                         |
| *Sewers/Pipe        |                       | 100-400 lf/day (m) | 200 lf/day (<36")       |                         |
|                     |                       |                    |                         |                         |
| *Mhls,Jnctn Bxs,CBs |                       |                    | 2/day, adj.-6/day       |                         |
| *Shldr Underdrains  |                       |                    | 1500 lf/day             |                         |
| *Edge Drains        |                       |                    |                         |                         |
| *Traff.Striping     |                       |                    | 10 mi/day (A.C.Pvmt)    |                         |
|                     |                       |                    | 6mi/day (PCC Pvmt)      |                         |
| *Culverts           |                       |                    |                         |                         |
|                     |                       |                    |                         |                         |
|                     |                       |                    |                         |                         |
| *Box Culverts       |                       |                    |                         | 10-15 cy/day (s)        |
|                     |                       |                    |                         | 60-75 cy/day (t)        |
| *Water Main         |                       |                    |                         |                         |
| *Gas Lines          |                       |                    |                         |                         |
| *Light Standards    |                       |                    |                         |                         |
| *Traffic Signals    |                       |                    |                         |                         |
| *Refl.Pvmt Mrkrs    |                       | 500-1000/day (w,x) | 1000-2000/day (y)       |                         |
| *OH Sign Struct.    |                       |                    |                         |                         |
| *Guardrail          |                       | 1500 lf/day (w)    | 500-1000 lf/day         | 1000 lf/day             |
| *Excavation         | 600 cy/day (Rdwy) (b) | uses curves        | 3000 cy/day (rural)     | 100-150 cy/day (Cl.III) |
|                     | 100 cy/day (Rdwy) (c) |                    | 1000 cy/day (urban)     |                         |
| *Borrow             | 600 cy/day            | uses curves        |                         |                         |
| *Mucking            |                       |                    | 3500 cy/day (lrg.proj)  |                         |
|                     |                       |                    | 1000ft-1/2mi/day(ditch) |                         |
| *Trenching          |                       |                    | 1000 lf/day             |                         |
| *Subbase & Sel.Sub. |                       |                    |                         |                         |
|                     |                       |                    |                         |                         |
| *Subgr.Undrct&Bckfl |                       |                    |                         |                         |
| *Scarify/Cmpct Rdbd |                       |                    | 1 mi/day                |                         |
| *Shape Roadbed      |                       |                    | 1 mi/day                |                         |
| *Stabilized Roadbed |                       | 5000 sy/day (bv)   |                         |                         |
| *Subbase Trtmt.     | 5 days (b)            |                    | 8000 sy or 1 mi/day     |                         |
|                     | 600 tons/day (c)      |                    |                         |                         |

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TABLE A-1.b - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM          | * MICHIGAN               | * MINNESOTA              | * NEW JERSEY            | * NORTH CAROLINA (cc)  |
|----------------------|--------------------------|--------------------------|-------------------------|------------------------|
| *Move-In             | * 10 days                | * 8 days                 | * 10 days               | *                      |
| *Clean up            | *10 days or 20 sta./day* |                          |                         | *                      |
| *Clear & Grub        | * 2 acres/day            |                          | * 4-10 acres/day (bw)   | * 1/4-10 acres/day (d) |
| *Seeding             | * 10 acres/day           | * 10 acres/day           | * 10000 sy/day          | * 1-3 acres/day (f)    |
| *Sodding             | * 2500 sy/day            | * 2500 sy/day            |                         | *                      |
| *Fence               | * 1200 lf/day (g)        | * 4000 lf/day (g)        | * 400 lf/day (h)        | * 300-2000 lf/day (i)  |
|                      | * 500 lf/day (h)         | * 2000 lf/day (h)        |                         | *                      |
| *Curb & Gutter       | * 2500 lf/day (k)        | * 2000 lf/day            | * 200-500 lf/day (l)    | * 100-1000 lf/day (ca) |
| *Sewers/Pipe         | * 40-120 lf/day (n)      | * 300 lf/day (<=24")     | * 50-120 lf/day (bx)    | * 50-300 lf/day (o)    |
|                      |                          | * 150 lf/day (>=30")     |                         | *                      |
| *Mhls,Jnctn Bxs,CBs* | * 3-4/day                | * 40 lf/day (48"diam.)   |                         | *                      |
| *Shldr Underdrains   |                          |                          |                         | *                      |
| *Edge Drains         |                          | * 4000 lf/day            |                         | *                      |
| *Traff.Striping      |                          |                          |                         | *                      |
| *Culverts            | * 120 lf/day (p)         | * 300 lf/day (<=24")     |                         | *                      |
|                      | * 150 lf/day (q)         | * 150 lf/day (>=30")     |                         | *                      |
|                      | * 5 days/unit (r)        |                          |                         | *                      |
| *Box Culverts        | * 5 days/pour            |                          |                         | *                      |
| *Water Main          | * 80-300 lf/day (u)      |                          |                         | *                      |
| *Gas Lines           | * 300 lf/day             |                          |                         | *                      |
| *Light Standards     | * 6 ea/day               |                          | * 4 units/day           | *                      |
| *Traffic Signals     |                          | * 15 days/intrsectn.(v)  | * 10 days/intrsectn.(v) | *                      |
| *Refl.Pvmt Mrkrs     |                          |                          |                         | *                      |
| *OH Sign Struct.     |                          |                          | * 5-7 days/unit         | *                      |
| *Guardrail           | * 750 lf/day             | * 750 lf/day             |                         | * 50-1500 lf/day (z)   |
| *Excavation          | *800-12000 cy/day (ab)   | *2000-10000 cy/day (ac)  | * 500-2000 cy/day (ae)  | * 100-8000 cy/day (af) |
|                      |                          | *1.5 substruct./day(ad)* |                         | *                      |
| *Borrow              |                          | *2000-10000 cy/day (aj)* |                         | *                      |
| *Mucking             | * 2000 cy/day            | * 2500 cy/day            |                         | *                      |
| *Trenching           |                          |                          |                         | *                      |
| *Subbase & Sel.Sub.* | * 20 sta./day (<=24ft)   |                          | * 50-350 cy/day (by)    | *                      |
|                      | * 15 sta./day (>24ft)    |                          |                         | *                      |
| *Subgr.Undrct&Bckfl* | * 2000 cy/day            |                          |                         | *                      |
| *Scarify/Cmpct Rdbd* |                          |                          |                         | *                      |
| *Shape Roadbed       |                          |                          |                         | *                      |
| *Stabilized Roadbed* |                          |                          |                         | *                      |
| *Subbase Trtmnt.     |                          |                          |                         | *                      |

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TABLE A-1.c - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *        | * NORTH DAKOTA *         | * OKLAHOMA *             | * WISCONSIN *            | * WYOMING *        |
|----------------------|--------------------------|--------------------------|--------------------------|--------------------|
| *Move-In             | *                        | 20-30 days               | *                        | 5-10 days          |
| *Clean up            | *                        | *                        | *                        | *                  |
| *Clear & Grub        | *                        | *                        | 10 sta./day              | *                  |
| *                    | *                        | *                        | *                        | *                  |
| *Seeding             | *                        | *                        | *20000 sy or 360 lb/day* | 40 acres/day       |
| *Sodding             | *                        | *                        | *                        | 5000-10000 sf/day  |
| *Fence               | *                        | *                        | 500 lf/day (g,h)         | 70-2000 lf/day (j) |
| *                    | *                        | *                        | *                        | *                  |
| *Curb & Gutter       | *                        | *                        | 500 lf/day               | 500 lf/day         |
| *Sewers/Pipe         | *                        | *                        | 100 lf/day               | 200 lf/day         |
| *                    | *                        | *                        | *                        | *                  |
| *Mhls,Jnctn Bxs,CBs* | *                        | *                        | *                        | 1-2/day            |
| *Shldr Underdrains   | *                        | *                        | *                        | *                  |
| *Edge Drains         | *                        | *                        | *                        | *                  |
| *Traff.Striping      | *                        | *                        | *                        | *                  |
| *                    | *                        | *                        | *                        | *                  |
| *Culverts            | *                        | *                        | *                        | 200-300 lf/day     |
| *                    | *                        | *                        | *                        | *                  |
| *                    | *                        | *                        | *                        | *                  |
| *Box Culverts        | *                        | *                        | *                        | *                  |
| *                    | *                        | *                        | *                        | *                  |
| *Water Main          | *                        | *                        | *                        | *                  |
| *Gas Lines           | *                        | *                        | *                        | *                  |
| *Light Standards     | *                        | *                        | *                        | *                  |
| *Traffic Signals     | *                        | *                        | *                        | *                  |
| *Refl.Pvmt Mrkrs     | *                        | *                        | *                        | *                  |
| *OH Sign Struct.     | *                        | *                        | *                        | *                  |
| *Guardrail           | *                        | *                        | *                        | (aa)               |
| *Excavation          | *1200-12800 cy/day (ag)* | *3000-10000 cy/day (ah)* | 300 cy/day (urban)       | (ai)               |
| *                    | *                        | *                        | 5000 cy/day (rural)      | *                  |
| *Borrow              | *                        | *                        | 350-1000 cy/day (ak)     | *                  |
| *Mucking             | *                        | *                        | *                        | *                  |
| *                    | *                        | *                        | *                        | *                  |
| *Trenching           | *                        | *                        | *                        | *                  |
| *Subbase & Sel.Sub.* | *                        | *                        | *                        | *                  |
| *                    | *                        | *                        | *                        | *                  |
| *Subgr.Undrct&Bckfl* | *                        | 0.5 mi/day               | *                        | *                  |
| *Scarify/Cmpct Rdbd* | *                        | *                        | *                        | *                  |
| *Shape Roadbed       | *                        | 2 days/mi.               | *                        | *                  |
| *Stabilized Roadbed* | *                        | *                        | *                        | *                  |
| *Subbase Trtmnt.     | *                        | *                        | *                        | *                  |
| *                    | *                        | *                        | *                        | *                  |

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TABLE A-2.3 - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| WORK ITEM              | ARKANSAS                 | FLORIDA            | LOUISIANA                | MARYLAND              |
|------------------------|--------------------------|--------------------|--------------------------|-----------------------|
| *Lime Treatment        | *                        | *                  | * 6000 sy/day (24 ft)    | *                     |
| *                      | *                        | *                  | * 5000 sy/day (20 ft)    | *                     |
| *Agg. Base Course      | * 3000 tons/day          | * uses curves      | * 6000 sy/day            | *                     |
| *                      | *                        | *                  | *                        | *                     |
| *Agg. Surf. Course     | *                        | *                  | * 300 cy/day             | *                     |
| *Agg. Shoulder         | *                        | *                  | *                        | *                     |
| *Base Course           | *600 cy/day(or tons)(b)* | * uses curves      | *1500 cy/day(non-stab.)* | *                     |
| *                      | *1000cy/day(or tons)(c)* | *                  | *1000 cy/day (Class I)   | *                     |
| *Bit. Pavement         | * 5 days (b)             | * uses curves      | *500-1000 tons/day (as)* | *                     |
| *                      | * 600 tons/day (c)       | *                  | *                        | *                     |
| *Cold Mix              | *                        | *                  | *                        | *                     |
| *Bit. Shoulder         | *                        | *                  | * 300 tons/day           | *                     |
| *                      | *                        | *                  | *                        | *                     |
| *Bit. Curb             | *                        | *                  | * 1000 ft/day            | *                     |
| *Prime/Tack Coat       | * 5 days (b) or          | *                  | * 5000 gal/day           | *                     |
| *                      | * 5000 gal/day (c)       | *                  | *                        | *                     |
| *Seal Coat             | *5 days (shldr) (b) or   | *                  | *                        | *                     |
| *                      | *2500 gal/day(shldr)(c)* | *                  | *                        | *                     |
| *Pntrt. Emuls. Concen* | *                        | *                  | *                        | *                     |
| *Slurry Seal           | *                        | *                  | *                        | *                     |
| *Surface Trtmt.        | *                        | * 200 cy/day       | *                        | *                     |
| *Pfab. Coal Tar Memb*  | *                        | *                  | *                        | *                     |
| *Breaking Bit. Pvmt.*  | *                        | *                  | * 10000 lf/day           | *                     |
| *Remov. Bit. Pvmt.     | *                        | *                  | * 1 mi/day               | *                     |
| *                      | *                        | *                  | *                        | *                     |
| *Mill Bit. Pvmt.       | *                        | * 4000 sy/day (bb) | * 5000-10000 sy/day      | *                     |
| *                      | *                        | *                  | *                        | *                     |
| *Conc. Pavement        | *                        | * 5000 sy/day      | * 2000 sy/day            | *                     |
| *                      | *                        | *                  | *                        | *                     |
| *Sidewalk              | *                        | * 300 sy/day       | *                        | *                     |
| *Conc. Shldr/Median    | *                        | *                  | *                        | *                     |
| *Conc. Med. Barrier    | *                        | *                  | * 500 lf/day             | *                     |
| *                      | *                        | *                  | *                        | *                     |
| *Epoxy Coating         | *                        | *                  | *                        | * 150 sy/day          |
| *Remove Conc. Pvmt     | *                        | *                  | * 500 sy/day             | * 10-15 cy/day (deck) |
| *Remove Curb           | *                        | *                  | *                        | *                     |
| *Remove Conc. Median*  | *                        | *                  | *                        | *                     |
| *Retaining Wall        | *                        | *                  | *                        | * 10-15 cy/day        |
| *Gabions               | *                        | *                  | *                        | *                     |

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TABLE A-2.b - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *        | * MICHIGAN *                               | * MINNESOTA *                                   | * NEW JERSEY *                               | * NORTH CAROLINA (cc) *  |
|----------------------|--|---|--|--------------------------|
| *Lime Treatment      |  |   |  |                          |
| *Agg. Base Course    |  | *3000 tons/day (rural)                          | * 50-350 cy/day or<br>* 250-2000 sy/day (al) | *200-3000 tons/day (an)* |
| *Agg.Surf.Course     |  |   |  |                          |
| *Agg. Shoulder       |  | * 2400 tons/day                                 |  |                          |
| *Base Course         |  |   |  | *300-600 tons/day (ap) * |
| *Bit.Pavement        | * 40 sta./day (24ft)<br>* 10 sta./day (at) | *1500-2400 tons/day(au)                         | *50-1000 tons/day (av)                       | *200-1500 tons/day (bz)* |
| *Cold Mix            |  |   |  |                          |
| *Bit.Shoulder        | *25 sta./day(1sid./crs)                    | * 600 tons/day (3 ft)<br>*1500 tons/day (10 ft) |  |                          |
| *Bit. Curb           |  |   |  |                          |
| *Prime/Tack Coat     |  |   |  | *2000-10000 sy/day (ay)* |
| *Seal Coat           |  |   |  |                          |
| *Pntrt.Emuls.Concen* |  |   |  |                          |
| *Slurry Seal         |  |   |  |                          |
| *Surface Trtmt.      |  |   |  |                          |
| *Pfab.Coal Tar Memb* |  |   |  |                          |
| *Breaking Bit.Pvmt.* |  |   |  |                          |
| *Remov.Bit.Pvmt.     | * 200 lf/day<br>* 1500 lf/day (az)         |   | * 150-1000 sy/day (ba)                       |                          |
| *Mill Bit. Pvmt.     |  | * 30000 sy-in/day (c)<br>* 12000 sy-in/day (bc) | *1000-2500 sy/day (bd)                       |                          |
| *Conc. Pavement      | * 15 sta./day (be)                         | * 10000 sy/day (bf)<br>* 2000 sy/day (bg)       | * 225-2500 sy/day (bh)                       | *1000-5000 sy/day (bi) * |
| *Sidewalk            | * 2000 sf/day (bl)                         | * 2500 sf/day                                   | * 100-225 sy/day (bm)                        |                          |
| *Conc.Shldr/Median   | * 15 sta.or 1500sy/day                     | * 4000 sy/day                                   |  |                          |
| *Conc.Med.Barrier    | * 1000 lf/day (k)                          | * 1200 lf/day (Pcst)<br>* 1500 lf/day (CIP)     |  |                          |
| *Epoxy Coating       |  |   |  |                          |
| *Remove Conc.Pvmt    |  | * 2000 sf/day (deck)                            |  |                          |
| *Remove Curb         |  |   | * 250-500 lf/day (bo)                        |                          |
| *Remove Conc.Median* |  |   |  |                          |
| *Retaining Wall      | * 1 panel/day (bq)                         |   |  |                          |
| *Gabions             |  |   |  |                          |

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TABLE A-2.c - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *          | * NORTH DAKOTA *        | * OKLAHOMA *            | * WISCONSIN *          | * WYOMING *               |
|------------------------|-------------------------|-------------------------|------------------------|---------------------------|
| *Lime Treatment        | *                       | *                       | *                      | *                         |
| *Agg. Base Course      | *600-5000 tons/day (an) | *500-1000 tons/day (ao) | *                      | * 2500-5000 tons/day      |
| *Agg. Surf. Course     | *                       | *                       | *                      | *                         |
| *Agg. Shoulder         | *                       | *                       | *                      | *                         |
| *Base Course           | *                       | *250-1000 tons/day (aq) | 2000 tons/day          | *1000-6000 tons/day (ar)  |
| *Bit. Pavement         | *600-2000 tons/day (aw) | *250-1000 tons/day (ax) | * 500 tons/day (urban) | *1500-2500 tons/day (wrg) |
|                        | *                       | *                       | *1000 tons/day (rural) | *                         |
| *Cold Mix              | *1 mi/day/lift (2" max) | *                       | *                      | * 1/2 mi/day              |
| *Bit. Shoulder         | *                       | *                       | * 1500 tons/day        | *                         |
| *Bit. Curb             | *                       | *                       | *                      | *                         |
| *Prime/Tack Coat       | * 2 mi/day              | *                       | *                      | * 5 mi/day (2-lane)       |
| *Seal Coat             | *4 mi or 20000 gal/day  | *                       | *                      | * 4-5 mi/day (2-lane)     |
| *Pntrt. Emuls. Concen* | *                       | *                       | *                      | * 2 mi/day (2-lane)       |
| *Slurry Seal           | *                       | *                       | *                      | * 1/2-1 lane mi/day       |
| *Surface Trtmnt.       | *                       | *                       | *                      | *                         |
| *Pfab. Coal Tar Memb*  | *                       | *                       | *                      | * 400 sy/day              |
| *Breaking Bit. Pvmt.*  | *                       | *                       | *                      | *                         |
| *Remov. Bit. Pvmt.     | *                       | *                       | * 1200 sy/day          | *                         |
| *Mill Bit. Pvmt.       | * 2000 tons/day         | *                       | *                      | *                         |
| *Conc. Pavement        | * 1/2 mi/day (rural)    | * 400-2000 sy/day (bj)  | * 1200 sy/day (urban)  | * 1 mi/day (bk)           |
|                        | *                       | *                       | * 5000 sy/day (rural)  | *                         |
| *Sidewalk              | *                       | *                       | * 500 sf/day (conc.)   | * 675 lf/day or 100 sy    |
| *Conc. Shldr/Median    | * 1 mi/day (10 ft)      | *                       | *                      | *                         |
| *Conc. Med. Barrier    | *                       | *                       | *                      | *                         |
|                        | *                       | *                       | *                      | * 2000 lf/day (cb)        |
| *Epoxy Coating         | *                       | *                       | *                      | *                         |
| *Remove Conc. Pvmt     | *1600-4300 sy/day (bn)  | *                       | *                      | *                         |
| *Remove Curb           | *                       | *                       | *                      | * 5000 lf/day (Bit.)      |
| *Remove Conc. Median*  | *                       | *                       | *                      | * 3000 lf/day (bp)        |
| *Retaining Wall        | *                       | *                       | *                      | *                         |
| *Gabions               | *                       | *                       | *                      | * 100-150 sy/day          |

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TABLE A-3.a - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *        | * ARKANSAS * | * FLORIDA * | * LOUISIANA *        | * MARYLAND *             |
|----------------------|--------------|-------------|----------------------|--------------------------|
| *BRIDGE WORK *       | *            | *           | *                    | *                        |
| *Remove Timb.Bridge* | *            | *           | 2 spans/day          | *                        |
| *Remove Conc.Bridge* | *            | *           | *                    | *                        |
| *Construct Bridge *  | *            | uses charts | 10-15 days/span (br) | *                        |
| *Conc. Footings *    | *            | *           | 15 cy/day            | *                        |
| *Substructure *      | *            | *           | 20-25 cy/day         | *                        |
| *Piling *            | *            | *           | 500 ft/day           | 200 lf/day (CPI)         |
| * *                  | *            | *           | *                    | *0.5 ea/day (Cylinder)   |
| * *                  | *            | *           | *                    | * 350 lf/day (H-piles)   |
| *Clms,Caps,Abtmnts*  | *            | *           | *                    | *                        |
| *Struct. Steel *     | *            | *           | *                    | 350-450 lf/day           |
| *Pstress.Conc.I-Bms* | *            | *           | *                    | 3-4 ea/day               |
| *Beam Erection *     | *            | *           | *                    | *                        |
| *Superstructure *    | *            | *           | *                    | 35-50 cy/day             |
| *Sdwk & Parapet *    | *            | *           | *                    | *                        |
| *Slp.Form Barrier *  | *            | *           | *                    | *                        |
| *Laytex Overlay *    | *            | *           | *                    | 2.5 cy/day               |
| *Railing Reconstr. * | *            | *           | *                    | *                        |
| *Replc.or Widn.Deck* | *            | *           | *                    | *                        |
| *Overlay Deck *      | *            | *           | *                    | *                        |
| *Low Slump Overlay * | *            | *           | *                    | *                        |
| *Mill Deck *         | *            | *           | *                    | *                        |
| *Clean Struct.Steel* | *            | *           | *                    | *6400 sf/day (by hand)   |
| *Paint *             | *            | *           | 120000 sf/day or     | *6000-32000 sf/day (bu)* |
| * *                  | *            | *           | 13333 sy/day         | *                        |
| *Sandblasting *      | *            | *           | *                    | 12800 sf/day             |

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TABLE A-3.b - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *          | * MICHIGAN *    | * MINNESOTA *      | * NEW JERSEY * | * NORTH CAROLINA (cc) * |
|------------------------|-----------------|--------------------|----------------|-------------------------|
| *BRIDGE WORK *         |                 |                    |                |                         |
| *Remove Timb. Bridge*  |                 |                    |                |                         |
| *Remove Conc. Bridge*  |                 |                    |                |                         |
| *Construct Bridge *    |                 |                    | (bs)           |                         |
| *Conc. Footings *      | 2 days/struct.  |                    |                |                         |
| *Substructure *        | 5 days/unit     |                    |                |                         |
| *Piling *              | 15/day (40 ft)  | 600 ft/day (ad)    |                | 15-25/day               |
| *Clnns, Caps, Abtmnts* |                 | 4 day/struct. (ad) |                |                         |
| *Struct. Steel *       | 3 days/span     |                    |                |                         |
| *Pstress. Conc. I-Bms* |                 |                    |                |                         |
| *Beam Erection *       |                 | 1 day/span (ad)    |                |                         |
| *Superstructure *      |                 | 9 days/span (ad)   |                |                         |
| *Sdwlk & Parapet *     | 5 days/span     |                    |                |                         |
| *Slp. Form Barrier *   | 2 days/bridge   |                    |                |                         |
| *Laytex Overlay *      |                 |                    |                |                         |
| *Railing Reconstr. *   |                 | 30 lf/day          |                |                         |
| *Replc. or Widn. Deck* |                 | 200 sf/day         |                |                         |
| *Overlay Deck *        | 13-15 days (bt) |                    |                |                         |
| *Low Slump Overlay *   |                 | 8000 sf/day (ad)   |                |                         |
| *Mill Deck *           |                 | 8000 sf/day (1/4") |                |                         |
| *Clean Struct. Steel*  |                 |                    |                |                         |
| *Paint *               | 5 spans/day     | 3 spans/day        |                | 2 spans/day             |
| *Sandblasting *        |                 |                    |                |                         |

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TABLE A-3.c - STANDARD PRODUCTION RATES FOR ESTIMATING WORKING DAYS

| * WORK ITEM *          | * NORTH DAKOTA * | * OKLAHOMA * | * WISCONSIN *  | * WYOMING *     |
|------------------------|------------------|--------------|----------------|-----------------|
| *BRIDGE WORK *         | *                | *            | *              | *               |
| *Remove Timb. Bridge*  | *                | *            | *              | 2-3 days *      |
| *Remove Conc. Bridge*  | *                | *            | *              | 3-5 days *      |
| *Construct Bridge *    | *                | *            | *              | *               |
| *Conc. Footings *      | *                | *            | *              | *               |
| *Substructure *        | *                | *            | 10 cy/day *    | *               |
| *Piling *              | *                | *            | *              | *               |
| *Clms, Caps, Abtmnts*  | *                | *            | *              | *               |
| *Struct. Steel *       | *                | *            | 25000 lb/day * | *               |
| *Pstress. Conc. I-Bms* | *                | *            | *              | *               |
| *Beam Erection *       | *                | *            | *              | *               |
| *Superstructure *      | *                | *            | 10 cy/day *    | *               |
| *Sdwk & Parapet *      | *                | *            | *              | *               |
| *Slp. Form Barrier *   | *                | *            | *              | *               |
| *Laytex Overlay *      | *                | *            | *              | *               |
| *Railing Reconstr. *   | *                | *            | *              | *               |
| *Replc. or Widn. Deck* | *                | *            | *              | *               |
| *Overlay Deck *        | *                | *            | *              | *               |
| *Low Slump Overlay *   | *                | *            | *              | *               |
| *Mill Deck *           | *                | *            | *              | *               |
| *Clean Struct. Steel*  | *                | *            | *              | *               |
| *Paint *               | *                | *            | *              | 800 sf/hr/gun * |
| *Sandblasting *        | *                | *            | *              | 2000 sf/day *   |

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# NOTES FOR STANDARD PRODUCTION RATE TABLES

- (a) 15 days (normal), 25 days (resurfacing)
  - (b) "Small" jobs
  - (c) "Large" jobs
  - (d) Major projects: 1-10 acres/day not to exceed 16 days  
Grading/Paving projects: 1-8 acres/day not to exceed 16  
Small rural widening projects: 1 acre/day  
Small urban projects: 1/4-1 acre/day
  - (e) Not to exceed 15 days
  - (f) Major projects: 1-3 acres/day not to exceed 16 days  
Grading/Paving projects same as major projects  
Small rural widening & small urban projects: 1-2 ac/day
  - (g) Woven wire
  - (h) Chainlink
  - (i) Major projects: 1000-2000 lf/day  
Grading/Paving projects: 500-1000 lf/day  
Small rural widening & small urban proj's: 300-500 lf/day
  - (j) 2000 lf/day (R/W fence), 640 lf/day (12ft snow fence-6wk delivery), 70-100 lf/day (screen fence w/6X6 posts-6wk delivery), 1200-1600 lf/day (filter fabric)
  - (k) Add 5 days cure time (minimum 7 days)
- |     |           |                |                  |               |                |                 |
|-----|-----------|----------------|------------------|---------------|----------------|-----------------|
| (l) |           | <u>Constr.</u> | <u>Reconstr.</u> | <u>Widen.</u> | <u>Resurf.</u> | <u>Intrsctn</u> |
|     | Barr.Type | 400lf/day      | 400              | 400           | 300            | N/A             |
|     | Vert.Type | 500            | 400              | 400           | 300            | 200             |
- (m) Municipal constr., includes pipe, inlets, manholes, etc.
  - (n) 120 lf/day (0-14ft up to 60"), 80 lf/day (0-14ft over 60"), 60 lf/day (14ft+ up to 60"), 60 lf/day (14ft+ over 60"), 40 lf/day (jacked in place)
  - (o) Major & Grading/Paving projects: 100-300 lf/day  
Small rural widening projects: 100-200 lf/day  
Small urban projects: 50-200 lf/day
  - (p) Rural highways
  - (q) Expressways
  - (r) Large headwalls
  - (s) Single cell
  - (t) Double/triple cell
  - (u) 80 lf/day (20"-42"), 300 lf/day (up to 16"), add 4-5 days for flushing, testing, and chlorination
  - (v) Installation time (does not include delivery time)
  - (w) When significant part of project
  - (x) 500/day (0-20000 ea), 1000/day (20000+ ea)
  - (y) 1000/day (traffic present), 2000/day (no traffic)
  - (z) Major projects: 500-1500 lf/day  
Grading/Paving projects: 300-500 lf/day  
Paving projects: 500-1500 lf/day  
Small rural widening projects: 100-500 lf/day  
Small urban projects: 50-300 lf/day
  - (aa) Remove (3000lf/day), remove corrugated beam (2000lf/day), Corrugated beam (single blocked out) (400lf/day), block out & add posts (750lf/day), Reset, block out and add posts to corrugated beam (single) (500lf/day), box beam (500-1000lf/day), posts (250-750 lf/day)
  - (ab) Freeway (12000 cy/day), grading (25 sta./day), embankment, lt-wt fill (800 cy/day), Reconstr. (5000 cy/day), widening (20 sta./day), gen. excav. for bridges (1000cy/day), excav. for footings (1day/unit)
- |      |                           |                |              |                  |
|------|---------------------------|----------------|--------------|------------------|
| (ac) |                           | <u>Scraper</u> | <u>Truck</u> | <u>Reconstr.</u> |
|      | Common exc.-plastic soils | 8000cy         | 5000cy       | 2000cy/day       |
|      | -gran. soils              | 10000cy        | 6000cy       | 2000cy/day       |
|      | Subgrade excavation       | 6000 cy        | 4000cy       | 2000cy/day       |
- (ad) For bridges over streams and three to four span grade separation units
  - (ae) Construction (2000 cy/day), reconstruction (500 cy/day)





- (af) (Unclassified, drainage ditch, Undercut, borrow)  
 Major project: 6000-8000 cy/day (Rock : 500-2000cy/day)  
 Grading/Paving project: 2000-6000 cy/day  
 Small rural widening projects: 200-400 cy/day  
 Small urban projects: 100-500 cy/day
- (ag) 0-20000cy: 1 scraper @ 150 yds/hr @ 8 hrs.= 1200 cy/day  
 20000-50000cy: 2 scrapers @ 180 yds/hr @ 8 hrs = 2880  
           cy/day use 2900 yds/day  
 50000-100000cy: use 3 scrapers @ 200 yds/hr @ 8 hrs.=  
           4800 yds/day  
 100000-250000cy: use 4 scrapers @ 200 yds/hr @ 8 hrs.=  
           6400 yds/day  
 250000-500000cy: use 5 scrapers @ 200 yds/hr @ 8 hrs.=  
           8000 yds/day  
 500000-1000000cy: use 6 scrapers @ 200 yds/hr @ 8 hrs.=  
           9600 yds/day  
 1000000-2000000cy: use 8 scrapers @ 200 yds/hr @ 8hrs.=  
           12800 yds/day
- (ah) Class "D" unclassified excavation  
 Under 200,000cy use 3,000 cy/day  
 200,000-300,000cy use 3,500 cy/day  
 300,000-400,000cy use 4,000 cy/day  
 400,000-500,000cy use 4,500 cy/day  
 500,000-600,000cy use 5,000 cy/day  
 600,000-700,000cy use 5,500 cy/day  
 700,000+cy use 6,000 cy/day  
 Extra large proj. use 10,000 cy/day
- (ai) Route  
 0.5 mi use 7,000-10,000 cy/day  
 up to 1000 ft use 400 cy/hr/unit  
 1000-2000 ft use 100 cy/hr/unit  
 Rock excavation use 2,000-3,000cy/day  
 Solid rock exc. use 500 cy/day
- (aj)
- |                | Scraper  | Truck   | Reconstruction |
|----------------|----------|---------|----------------|
| Plastic soils  | 8000 cy  | 5000 cy | 2000 cy/day    |
| Granular soils | 10000 cy | 6000 cy | 2000 cy/day    |
- (ak) 1000 cy/day/unit (T-pull), 350 cy/day/unit (truck)
- (al) (6" thick) Constr. Reconstr. Widening Intersctns  
           350cy/day 250cy/day 150cy/day 50cy/day  
           or 2000sy/day 1500sy/day 1000sy/day 250sy/day
- (am) Major projects: 1000-2500 tons/day(mainline), 500-1200  
 tons/day(Y-lines & ramps)  
 Grading/Paving projects: 1000-3000 tons/day  
 Paving projects: 1000-2500 tons/day(mainline, if  
   tot.qty. > 40,000 tons), 500-1200 tons/day (Y-lines &  
   ramps)  
 Small rural widening projects: 300-500 tons/day  
 Small urban projects: 200-500 tons/day  
 (SOIL TYPE)  
 Major projects: 2000-3000 cy/day  
 Grading/Paving projects: 1000-2000 cy/day  
 Paving projects: 2000-3000 tons/day  
 Small rural widening projects: 300-500 cy/day  
 Small urban projects: 200-500 cy/day



- (bh) Construction (2,500 sy/day), reconstruction (1,000 sy/day), widening (750 sy/day), intersections (225 sy/day)
- (bi) All projects (3,000-5,000 sy/day), Ramps (1,000-1,500 sy/day + 2 days for turnout tapers)
- (bj) Municipal paving (400 sy/day), rural paving (800-1,000 sy/day), large four-lane (2,000 sy/day)
- (bk) One-lane, 24ft. X 8in.
- (bl) For sidewalk patching use 700 sf/day
- (bm) Concrete, construction (225 sy/day), reconstruction & widening (175 sy/day), resurfacing (150 sy/day), intersections (100 sy/day)
- (bn) Rural (4,300 sy/day or 1500 lf/day), urban (1,600 sy/day)
- (bo) Reconstruction (500 lf/day), widening, resurfacing, intersections (250 lf/day)
- (bp) 4ft. wide, 4in. thick, with curbs
- (bq) 10 days minimum
- (br) Based on 20ft. span (CIP)
- (bs) See Figure A.1 on page 118
- (bt) Entire deck, traffic removed (15 days), 1/2 deck with traffic interference (13 days)
- (bu) 4-man crew, brush (6,000-8,000 sf/day/coat), roller (8,000-16,000 sf/day/coat), airless spray (32,000 -48,000 sf/day/coat), conventional spray (16,000 -32,000 sf/day/coat)
- (bv) Not to exceed 10 days
- (bw) Construction and reconstruction (4 acres/day), widening and resurfacing (10 acres/day)
- (bx) Includes one structure. Construction (200 lf/day), reconstruction (100 lf/day), widening and intersections (50 lf/day)
- (by) Construction (350 cy/day), reconstruction (250 cy/day), widening (150 cy/day), intersections (50 cy/day)
- (bz) Major projects and paving projects: 800-1500 tons/day (mainline), less than 800 tons/day for ramps and Y-lines  
 Grading/Paving projects: 300-1,000 tons/day  
 Small rural widening projects: 200-600 tons/day  
 Small urban projects: 200-500 tons/day
- (ca) Major projects and paving projects: 500-1,000 lf/day (mainline), 200-400 lf/day (Y-lines)  
 Grading/Paving projects: 100-500 lf/day  
 Small rural widening and small urban projects: 100-300 lf/day
- (cb) Temporary
- (cc) North Carolina describes Major projects as "Major Urban and Rural Projects" with grading in excess of 1,000,000 cy, and Grading/Paving projects as those type projects with less than 1,000,000 cy of grading



- (an) 0-5,000 tons use 4 trucks @ 15 t/load @ 10 loads/day = 600 tons/day  
 5,000-10,000 tons use 6 trucks @ 15 t/load @ 10 loads/day = 900 tons/day  
 10,000-25,000 tons use 8 trucks @ 18 t/load @ 10 loads/day = 1,440 tons/day  
 25,000-50,000 tons use 8 trucks @ 18 t/load @ 14 loads/day = 2,000 tons/day  
 50,000-100,000 tons use 12 trucks @ 18 t/load @ 14 loads/day = 3,000 tons/day  
 100,000-200,000 tons use 16 trucks @ 18 t/load @ 14 loads/day = 4,000 tons/day  
 200,000 tons and up use 20 trucks @ 18 t/load @ 14 loads/day = 5,000 tons/day
- (ao) Stabilized Aggregate Base  
 Under 40,000 tons use 500 tons/day  
 40,000-75,000 tons use 750 tons/day  
 Over 75,000 tons use 1,000 tons/day  
 Soil Asphalt Bases, 8" use 4 mi/day, 6" use 3 mi/day, add 1 day for each 2,000-2,500 sy of material hauled.  
 PC Treated Base (Shoulders), 1 day/2,000-2,500 sy
- (ap) Sand asphalt
- (aq) Bituminous Base-Fine or Course Aggregate  
 Under 15,000 tons use 250 tons/day  
 15,000-30,000 tons use 500 tons/day  
 30,000-75,000 tons use 750 tons/day  
 Over 75,000 tons use 1,000 tons/day
- (ar) Plant mix base (4,000-6,000 tons/day), streets (1,000 tons/day), 1.5 mi. haul (2,000-3,000 tons/day)
- (as) Large project (1,000 tons/day), overlay (500-800 tons/day), friction course-60 lb/sy (7,000-10,000 sy/day), widening one-side (50 sta./day)
- (at) 16ft. wide ramps, add 5 days cure time-minimum 7 days
- (au) Rural or minimum degree of difficulty: Leveling course (2,000 tons/day), base course (2,400 tons/day), Binder course (2,000 tons/day), Wearing course (>1" use 2,000 tons/day, <=1" use 1,500 tons/day)
- (av) Construction, widening, resurfacing (1,000 tons/day), reconstruction (750 tons/day), inter-sections (50 tons/day)
- (aw)
- |                              | Hot Bit.      | Recycled HBP  |
|------------------------------|---------------|---------------|
| 0-20,000 tons (100t/hr)      | 800 tons/day  | 600 tons/day  |
| 20,000-40,000 tons (150t/hr) | 1200 tons/day | 900 tons/day  |
| 40,000-80,000 tons (225t/hr) | 1800 tons/day | 1350 tons/day |
| 80,000 tons and up (250t/hr) | 2000 tons/day | 1500 tons/day |
- (ax) Under 15,000 tons use 250 tons/day  
 15,000-30,000 tons use 500 tons/day  
 30,000-75,000 tons use 750 tons/day  
 Over 75,000 tons use 1,000 tons/day
- (ay) Bituminous surface treatment-small urban projects use 2,000-5,000 sy/day, all other projects use 5,000-10,000 sy/day
- (az) For recycling (24 ft)
- (ba) Reconstruction & widening (1,000 sy/day), resurfacing (500 sy/day), intersections (150 sy/day)
- (bb) Not to exceed 20 days
- (bc) Urban reconstruction
- (bd) Up to 2" thick, Reconstruction, widening, resurfacing (2,500 sy/day), intersections (1,000 sy/day)
- (be) 24ft wide, add 5 days cure time, minimum 7 days
- (bf) Standard width
- (bg) Non-standard width





CONTRACTOR PRODUCTIVITY IN WORKING DAYS FOR BRIDGES

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| SIZE OF BRIDGE                                      | TYPE 1<br>CONSTRUCTION | TYPE 2<br>REPLACEMENT | TYPE 3<br>SUPERSTRUCTURE | TYPE 4<br>DECK | TYPE 5<br>OVERLAY |
|---|------------------------|-----------------------|--------------------------|----------------|-------------------|
| ONE SPAN  |                        |                       |                          |                |                   |
| 2 LANES   | 100                    | 120                   | 50                       | 45             | 30                |
| 4 LANES   | 120                    | 150                   | 60                       | 55             | 35                |
| 6 LANES   | 130                    | 170                   | 70                       | 60             | 40                |
| TWO SPANS   |                        |                       |                          |                |                   |
| 2 LANES   | 130                    | 160                   | 60                       | 55             | 35                |
| 4 LANES   | 150                    | 180                   | 70                       | 65             | 40                |
| 6 LANES   | 160                    | 190                   | 80                       | 75             | 45                |
| FOR EACH ADDITIONAL<br>SPAN, ANY NUMBER<br>OF LANES | 10/Span                | 5/Span                | 5/Span                   | 5/Span         | 5/Span            |
| COFFERDAMS  | 20                     | 20                    | N/A                      | N/A            | N/A               |
| PILES   | 10                     | 10                    | N/A                      | N/A            | N/A               |

NOTES:

1. For two bridges add 50%, for each additional bridge add 25%
2. For stage construction, consider each stage to be a separate bridge
3. For bridges over water or railroads add 30 days, except for Type 5 for which no adjustment is necessary.

TYPE 1 = New construction on new alignment

TYPE 2 = Remove existing and construct new at same location

TYPE 3 = Replace deck and beams including minor substructure repair

TYPE 4 = Replace deck

TYPE 5 = Deck patching and LMC overlay (subtract 10 days if overlay is bituminous concrete)

Figure A.1 Productivity Rates for Bridges (New Jersey)





APPENDIX B  
FDOT SPECIFICATIONS



1-7 Calendar Day.

Every day shown on the calendar, ending and beginning at Midnight.

1-11 Contract Time.

The number of work days or calendar days allowed for completion of the contract, including authorized time extensions.

In case a calendar date of completion is stipulated in lieu of a number of work or calendar days, the contract shall be completed by such calendar date.

5-8 Contractor's Supervision.

5-8.1 Prosecution of Work: The Contractor shall give the work the constant attention necessary to assure the scheduled progress and he shall cooperate fully with the Engineer and with other Contractors at work in the vicinity.

5-8.2 Contractor's Superintendent: The Contractor shall at all times have on the work as his agent, a competent superintendent capable of thoroughly interpreting the plans and specifications and thoroughly experienced in the type of work being performed, who shall receive the instructions from the Engineer or his authorized representatives. The superintendent shall have full authority to execute the orders or directions of the Engineer and to supply promptly any materials, tools, equipment, labor and incidentals which may be required. Such superintendence shall be furnished regardless of the amount of work sublet.

5-8.3 Supervision for Emergencies: The Contractor shall have a responsible person available at or reasonably near the work site on a 24-hour basis, seven days a week, in order that he may be contacted in emergencies and in cases where immediate action must be taken to maintain traffic or to handle any other problem that might arise. For compliance with this requirement outside of working hours, the furnishing of the telephone number where such person can be reached will suffice.

5-10 Final Construction Inspection.

5-10.1 Maintenance until Final Acceptance: The Contractor shall maintain all work in first-class condition until it has been completed as a whole and has been accepted by the Engineer under the provisions of 5-11, provided that on non-Federal-Aid projects the work may be accepted in sections as designated by the Engineer, and the Contractor relieved of maintenance of such sections after acceptance.



5-10.2 Semifinal Inspection: The Engineer will make a semifinal inspection within seven days after notice from the Contractor of presumptive completion of the entire project. If, at the semifinal inspection, all construction provided for and contemplated by the contract is found completed to the Engineer's satisfaction, such inspection shall constitute the final inspection, as prescribed below. If, however, at any semifinal inspection any work is found unsatisfactory, in whole or in part, the Engineer shall give the Contractor the necessary instructions as to replacement of material and performance or reperformance of work necessary and prerequisite to final completion and acceptance, and the Contractor forthwith shall comply with and execute such instructions. Upon satisfactory replacement of material and performance or reperformance of such work, another inspection shall be made, which shall constitute the final inspection if the required material is found to have been replaced and the work completed satisfactorily.

5-10.3 Final Inspection: Whenever all materials have been furnished, all work has been performed, and the construction contemplated by the contract has been satisfactorily completed, the Engineer will make the final inspection.

#### 5-12 Claims by Contractor.

Where the Contractor deems that extra compensation is due him for work or materials not clearly covered in the contract or not ordered by the Engineer as extra work, as defined herein, the Contractor shall notify the Engineer in writing of his intention to make claim for extra compensation, before he begins the work on which he bases the claim. If such notification is not given, and the Engineer is not afforded proper opportunity for keeping strict account of actual cost, as defined for force account, then the Contractor thereby agrees to waive the claim for such extra compensation. Such notice by the Contractor, and the fact that the Engineer has kept account of the cost as aforesaid, shall not in any way be construed as establishing the validity of the claim. In case the claim, after consideration by the Engineer, is found to be valid, it shall be allowed and paid for as an extra as provided herein. Nothing in this Article shall be construed as establishing any claim contrary to the terms of 4-3.

### SECTION 8 PROSECUTION AND PROGRESS

#### 8-1 Subletting or Assigning of Contracts.

8-1.1 General: The Contractor shall not sublet, sell, transfer, assign or otherwise dispose of the contract or contracts or any portion thereof, or of his right, title, or interest therein, without written consent of the Department. With the Engineer's written consent the Contractor will be permitted to sublet a portion of the work but shall perform with his own organization work amounting to not less than 50





percent of the total contract amount less the total amount for those contract items designed as "Specialty Work."

The total contract amount shall include the cost of materials, manufactured component products and their transportation to the project site. Off-site commercial production of materials and manufactured component products purchased by the Contractor and their transportation to the project shall not be considered subcontracted work.

If a part of a contract item is sublet, only its proportional cost shall be used in determining the percentage of subcontracted normal work.

All agreements to sublet work shall be in writing and must contain all pertinent provisions and requirements of the contract. Upon request, the Contractor shall furnish to the Department a copy of the subcontract. Subletting of work shall not relieve the Contractor or the surety of their respective liabilities.

A subcontractor shall be recognized only in the capacity of an employee or agent of the Contractor, and his removal may be required by the Engineer, as in the case of an employee.

8-1.2 Specialty Work: For normal road and bridge contracts Specialty Work is defined as work of a type not normally performed by road and bridge contractors with their own organizations.

The following work is specifically designated as Specialty Work for normal road and bridge construction. (Note: This listing does not apply to Federal Aid contracts. The Specialty Work for these contracts will be shown in the special provisions for the individual jobs.)

- Grassing and Sodding Work.
- Reworking Shoulders
- Milling Existing Pavement
- Removal of Buildings.
- Fencing Work.
- Painting.
- Electrical Work.
- Roadway and Bridge Lighting.
- Navigation Lights.
- Buildings, including Control House and Operator's House.
- Sanitary Sewers.
- Water Lines and Appurtenances.
- Machinery and Castings for Movable Bridges.
- Auxiliary Power Unit.
- Pumping Equipment.
- Riprap.
- Landscaping Work.
- Signalization System.
- Installing Pipe or Pipe Liner, by jacking.
- Installing Structural Plate Pipe Structures.
- Roadway Signing and Pavement Marking.
- Pit Scales.





Plugging Water Wells.  
Vehicular Impact Attenuator.  
Guardrail.  
Temporary Traffic Control Devices.

When the major work under the contract is of a type not normally performed by road and bridge contractors, the above-listed work will be considered as Specialty Work only as so listed in the special provisions.

## 8.2 Work Performed by Equipment-Rental Agreement.

The limitations set forth in 8-1, as to the amount of work that may be sublet, do not apply to work performed by equipment-rental agreement. However, for any work proposed to be performed by equipment-rental agreement the Contractor shall notify the Engineer in writing of such intention before using the rented equipment, and shall indicate whether the equipment is being rented on an operated or non-operated basis. The Contractor's written notice shall contain a listing and description of the equipment and a description of the particular work to be performed with such equipment. As an exception to the above requirements for a written notice to the Engineer, such notice will not be required for equipment to be rented (without operators) from an equipment dealer or from a firm whose principal business is the renting or leasing of equipment.

The operators of all rented equipment, whether rented on an operated or a non-operated basis, will be subject to all wage rate requirements applicable to the project. If equipment is being rented without operators the Contractor will be required to carry the operators on his own payroll. When equipment is rented on an operated basis the Contractor, when required by the contract or requested by the Engineer, shall furnish payrolls from the lessor with the names of the operators shown thereon.

Where rentals of equipment on an operated basis, from the same lessor, exceed \$10,000, such lessor will be subject to any Equal Employment Opportunity requirements which may be applicable to the project.

## 8-3 Prosecution of Work.

**8-3.1 Compliance with Time Requirements:** The Contractor shall commence work in accordance with his approved working schedule and shall provide sufficient labor, materials and equipment to insure the completion of the work within the time limit set forth in the proposal. Should the Contractor fail to furnish sufficient and suitable equipment, forces and materials, as necessary to assure the progress of the work in accordance with the required schedule, the Engineer may withhold all estimates which are, or may become due, or may suspend the work until such deficiencies are corrected.

**8-3.2 Submission of Working Schedule:** Within 30 days after the contract has been awarded, the successful bidder shall submit to the



Department, on a prescribed form, a working schedule for the project, showing in detail the working day on which he expects to begin and complete each of the various major items of the work.

8-3.3 Beginning Work: The Contractor shall notify the District Engineer of his intention to begin work, not less than five days in advance of the date on which he proposes to begin and, upon the receipt of such notice from the Contractor, the District Engineer may give the Contractor notice to proceed, and may designate the point or points at which the work is to be started. In the notice to proceed the Engineer may waive the five-days advance notice from the Contractor and authorize him to begin immediately. The Contractor shall notify the Engineer in writing at least two days in advance of the date on which he expects to begin important features of the work. No work under the contract shall be commenced until after the notice to proceed has been issued. The notice to proceed will be issued within 30 days after execution of the contract by the Department.

8-3.4 Provisions for Convenience of Public: The Contractor shall schedule his operations so as to minimize any inconvenience to adjacent businesses or residences. Where necessary, the Engineer may require the Contractor to construct first the work in any areas along the project where restrictions caused by construction operations would present a more serious handicap, before beginning construction in the less-affected areas. In such critical locations, where there is no assurance of continuous effective prosecution of the work once the construction operations are begun, the Engineer may require that the work of removal of the existing (usable) facilities in such areas be delayed as is necessary and practicable.

8-3.5 Preconstruction Conference: Immediately after the Contract has been awarded, the Engineer will call a preconstruction conference to be held before any work is begun at a place designated by him, to go over the construction aspects of the project. The meeting will be between the Contractor, the Department, and the various utility companies which will be involved by the road construction. The Contractor shall have on hand for this meeting, a tentative working schedule for the project, in detail, showing his proposed operations for the various items of work which would affect or be affected by utility or railroad adjustments. The various utility or railroad companies will then establish their own working schedule under the direction of the engineer so as to coincide to the greatest degree practical with the schedule of the Contractor so that all work under the Contract may be diligently prosecuted. No work under the Contract shall be commenced until after the notice to proceed has been issued by the Engineer.

#### 8-4 Limitations of Operations.

8-4.1 Night Work: In general, all work shall be performed during daylight hours. For special operations, night work may be done if so authorized in writing. No night work shall be performed unless adequate artificial lighting has been provided and has been approved.





8-4.2 Sequence of Operations: The Contractor shall not open up work to the prejudice of work already started, and the Engineer may require the Contractor to finish a section on which work is in progress before work is started on any additional section.

8-4.3 Interference with Traffic: The Contractor shall at all times conduct the work in such manner and in such sequence as to insure the least practicable interference with traffic. The Contractor's vehicles and other equipment shall be operated in such manner that they will not be a hazard or hinderance to the traveling public. Materials stored along the roadway shall be placed so as to cause as little obstruction to the traveling public as possible.

To prevent any open trench remaining after working hours where existing pavement is to be widened and stabilizing is not required the Contractor shall schedule his operations such that at the end of each work day the full thickness of the base for widening will be in place. Construction of the widening strips will not be permitted simultaneously on both sides of the road except where separated by a distance of at least one-fourth mile along the road, where either the work of excavation has not been started or the base has been completed.

8-4.4 Coordination with other Contractors: The Contractor shall arrange his work and dispose of his materials so as to not interfere with the operations of other contractors engaged upon adjacent work and to join his work to that of others in a proper manner, in accordance with the spirit of the plans and specifications, and to perform his work in the proper sequence in relation to that of other contractors, all as may be directed by the Engineer.

Each contractor will be held responsible for any damage done by him or his agents to the work performed by another contractor.

8-4.5 Drainage: The contractor shall so conduct his operations and maintain the work in such condition that adequate drainage will be in effect at all times. Existing functioning storm sewers, gutters, ditches, and other run-off facilities shall not be obstructed.

8-4.6 Fire Hydrants: Fire hydrants on or adjacent to the highway shall be kept accessible to fire apparatus at all times and no material or obstruction shall be placed within 15 feet of any such hydrant.

8-4.7 Protection of Structures: Heavy equipment shall not be operated close enough to pipe headwalls or other structures to cause their displacement.

8-4.8 Fencing: On all projects which include fencing and where the Engineer determines it to be necessary for maintaining the security of livestock or adjacent property, or for protection of pedestrians who are likely to gain access to the project from adjacent property, the Contractor shall erect permanent fence as a first order of business.



## 8.5 Qualifications of Contractor's Personnel.

The Contractor shall assure that all superintendents, foremen and workmen employed by him are competent, careful and reliable. All workmen must have sufficient skill and experience to properly perform the work assigned them. All workmen engaged on special work, or skilled work such as bituminous courses or mixtures, concrete bases, pavements, or structures, or in any trade, shall have had sufficient experience in such work to perform it properly and satisfactorily and to operate the equipment involved, and shall make due and proper effort to execute the work in the manner prescribed in the specifications, or the Engineer may take action as prescribed below.

Whenever the Engineer shall determine that any person employed by the Contractor is incompetent, unfaithful, intemperate, disorderly or insubordinate, such person shall, upon notice, be discharged from the work and shall not again be employed on it except with the written consent of the Engineer. Should the Contractor fail to remove such person or persons the Engineer may withhold all estimates which are or may become due, or may suspend the work until such orders are complied with. The Contractor shall protect, defend, indemnify and hold the Department, its agents, officials and employees harmless from any and all claims, actions or suits arising from such removal, discharge or suspension of employees.

## 8-6 Temporary Suspension of Work.

8-6.1 Authority to Suspend Work: The Engineer shall have the authority to suspend the work, wholly or in part, for such period or periods as may be deemed necessary, due to unsuitable weather or other conditions which are considered unfavorable for the prosecution of the work, or for such time as is necessary due to the failure on the part of the Contractor to carry out orders given or to comply with any or all provisions of the contract. Such suspension shall be ordered in writing, giving in detail the reasons for suspension.

8-6.2 Prolonged Suspensions: If for any reason it should become necessary to stop work for an indefinite period, the Contractor shall store all materials in such manner that they will not obstruct or impede the traveling public unnecessarily, nor become damaged in any way, and he shall take every reasonable precaution to prevent damage to or deterioration of the work performed, shall provide suitable drainage of the roadway by opening ditches, shoulder drains, etc., and shall provide any temporary structures necessary for public travel or convenience.

8-6.3 Permission to Suspend Work: The Contractor shall not suspend operations or remove equipment or materials necessary for the completion of the work without the permission of the Engineer.

### 8-6.4 Contractor's Vacation:

8-6.4.1 Length of Vacation: The Contractor will be allowed to suspend operations for a period not to exceed 14 days annually, in order to provide vacation time for his employees. These 14 days may be divided into no more than two separate periods of vacation time.





8-6.4.2 Automatic Time Suspension: Two periods of time are established for automatic time suspension. These periods are Thanksgiving, which includes Thanksgiving Day and the following Friday, Saturday and Sunday; and Christmas, which includes December 24th through January 1st. Vacation days other than provided at Thanksgiving and Christmas will require written request as specified in 8-6.4.3.

These automatic time suspensions may be approved verbally by the Project Engineer upon notification by the Contractor of his intent to shut down his operations for one or both of these periods. If the Contractor does not shut down his operations during these periods, contract time will be charged as usual.

8-6.4.3 Request for Vacations at Other Times: The Contractor shall submit written request to the District Engineer for permission to suspend operations, other than those specified in 8-6.4.2, at least 30 days in advance of the date of suspension.

8-6.4.4 Refusal of the Request: The Department reserves the right to refuse permission for a suspension (including automatic suspensions) when it might cause undue inconvenience to the traveling public or when, because of other factors, uninterrupted prosecution of the work is essential.

8-6.4.5 Minimum Staffing During Suspensions: The Contractor shall retain sufficient personnel at the job site to properly maintain all signs, warning devices and lights.

8-6.4.6 Contract Time Not Charged: Contract time will not be charged during the period of any approved suspension for vacation, as long as no work (with the exception of that specified in 8-6.4.5 is accomplished on the project.

## 8-7 Computation of Contract Time.

**8-7.1 General:** The Contractor shall perform fully, entirely and in accordance with the specifications, the contracted work within the contract time specified in the proposal, or as may be extended in accordance with the provisions hereinbelow.

The allowable contract time is calculated with consideration given that significant work is not normally accomplished on Saturdays, Sundays, State Legal Holidays and during seasonal inclement weather conditions with accompanying normal delays in prosecution of work on controlling items.

The effect on job progress of utility relocation and adjustments and the scheduling of construction operations required in order to adequately maintain traffic, as detailed in the plans and/or scheduled in the special provisions, has also been considered in the computation of the allowable contract time.

**8-7.2 Date of Beginning of Contract Time:** The date on which contract time will begin shall be either (1) the date of which the



Contractor actually begins work or (2) the date for beginning the charging of contract time as set forth in the proposal, whichever is earlier.

### 8-7.3 Adjusting Contract Time:

8-7.3.1 Increased Work: If the amount of the contract is increased due to net variations in estimated quantities or due to work added or extra work, then the contract time will be increased in the same proportion that the increased amount bears to the original contract amount.

8-7.3.2 Contract Time Extensions: The Department may grant an extension of the allowable contract time when a controlling item of work is delayed by factors determined to be beyond the Contractor's control which could not be reasonably anticipated at the time bids for the project were received. When failure by the Department to fulfill an obligation under the contract results in delays in the controlling construction operations, such delays will be considered as a basis for granting credit to the contract time. Extensions of contract time will not be granted for delays due to the fault or negligence of the Contractor.

Rains or other inclement weather conditions and related adverse soil conditions will be considered as the basis for granting of a time extension only when such conditions are unseasonable, provided that the project records indicate that they did in fact delay one or more controlling items of work.

Delays in delivery of materials or component equipment which affects progress on a controlling item of work will be considered as basis for granting a time extension if such delays are beyond the control of the Contractor or supplier. Such delays might be an area-wide shortage, an industry-wide strike or a natural disaster which affects all feasible sources of supply. In general, the Contractor shall furnish substantiating letters from a representative number of manufacturers of such materials or equipment clearly confirming that the delay in delivery was in no way the fault of the Contractor.

Requests for time extension due to delay in the delivery of custom manufactured equipment such as traffic signal equipment, highway lighting equipment, etc., will not be considered unless the Contractor furnishes documentation that his order for such equipment was placed in a timely manner, the delay was caused by factors over which the manufacturer could not be reasonably expected to exercise control and the lack of such equipment did cause a delay in progress on a controlling item of work.

The affect of utility relocation and adjustment work on job progress will be considered as the basis for granting a time extension only if all the following criteria are met:

1. Delays are the result of utility work not detailed in the plans or utility work detailed in the plans which is not accomplished





- in reasonably close accordance with the schedule included in the special provisions.
2. Utility work actually affected progress toward completion of controlling work items.
  3. The Contractor took all reasonable measures to minimize the effect of utility work on job progress including cooperative scheduling of his operations with the scheduled utility work at the preconstruction conference and providing adequate advance notification as given to utility companies as to the dates on which their operations must be coordinated with the Contractor's operation to avoid delays.

It is incumbent on the part of the Contractor to request any extension of the allowable contract time which he deems appropriate promptly after completion of the controlling work items which were delayed. Requests, if made after completion of the project, shall be submitted within 45 calendar days from the date of final acceptance of the project. The request must contain a detailed tabulation including dates and events fully describing the magnitude of the delays to controlling items of work caused by unanticipated factors beyond the control of the Contractor. The tabulation must consider overlapping periods of delay when there is more than one delaying factor.

8-7.3.3 Suspension Not Caused by Contractor: Whenever the work is suspended by the Engineer as provided in 8-6, for reasons other than the fault of the Contractor, allowance for any delay in completion of the work due to such suspension shall be made.

## 8-8 Failure of Contractor to Maintain Satisfactory Progress.

8-8.1 General: Time is an essential element of the contract and, as delay in the prosecution of the work will inconvenience the public, obstruct traffic, and interfere with business, it is important that the work be pressed vigorously to completion. Moreover, the cost to the Department for the administration of the contract, including engineering, inspection, and supervision, will be increased as the construction period is lengthened.

Chapter 337 of the Florida Transportation Code and Rules of the Department establish certain requirements pertaining to the suspension or revocation of a Contractor's certificate of qualification because of delinquency on a previously awarded contract.

8-8.2 Interpretation of Terms: Whenever in this Section the terms "delinquent" and "disqualified" appear, they are intended to mean disqualification only from bidding on other of the Department's contracts, and from approval as a subcontractor.

### 8-8.3 Regulations Governing Disqualification:

(a) A Contractor may be declared delinquent because of unsatisfactory progress on a contract with the Department, when the



contract time allowed has not been entirely consumed, but the Contractor's progress at any check period does not meet at least one of the following two tests:

- (1) The percentage of dollar value of completed work with respect to the total amount of the contract is within ten percentage points of the percentage of contract time elapsed.
- (2) The percentage of dollar value of completed work is within ten percentage points of the dollar value which should have been performed according to the Contractor's own progress schedule previously approved by the Engineer.

In lieu of the "ten percentage points" stipulated in the two preceding paragraphs, 20 percentage points may be allowed for a Contractor who, in the opinion of the Director, Division of Construction, has adequate organization, equipment, and financial resources to undertake other contract or subcontract work without conflict or delay in prosecuting work under existing contracts let by the Department.

(b) A Contractor will be declared delinquent because of unsatisfactory progress on the contract with the Department, under either of the following circumstances:

- (1) The Contract time allowed has been consumed and the work has not been completed.
- (2) The contract time allowed has not been entirely consumed, but the Contractor's progress at any check period does not meet either of the two tests described under the paragraphs headed (a) above.

(c) A Contractor declared delinquent under the provisions of 8.8 will be disqualified from further bidding and also will not be approved as a subcontractor so long as the delinquent status exists. Also, any individual, firm, partnership or corporation, affiliated with a delinquent Contractor to the extent that it is dependent upon the delinquent Contractor for either personnel, equipment or finances, shall likewise be disqualified.

(d) The Contractor may appeal to the Secretary of the Department for relief from his disqualification status. The Secretary will act upon any appeal within 30 calendar days after the filing thereof, and will promptly notify the appellant of the action taken.

(e) A Contractor disqualified under the requirements of this Article will be removed from such status upon receipt of evidence from the Department's District Engineer that his progress is no longer delinquent, provided the contract time has not elapsed.

(f) The principal progress check period will occur monthly, upon receipt in Tallahassee of the Contractor's monthly estimates. Postings will generally be completed by the first week of each month, and preliminary notices of delinquency will be sent to the Contractor by telegram immediately thereafter, and confirmed by certified mail.

(g) No Contractor given such a preliminary notice of delinquency will be finally declared delinquent until a period of ten calendar days after the preliminary notice has elapsed. During this ten-day period the affected Contractor may request any extensions of time, or other considerations which would affect his delinquency, which he feels he is entitled to.





(h) Final notification of delinquency will be made by telegram and certified mail after the expiration of this ten-day period, provided no extensions of time or other considerations are deemed proper by the Department, and provided the delinquency status has not been corrected.

(i) The Department may grant extensions of time during the prosecution of the work, as allowed under the Standard Specifications and special provisions for the work, regardless of the Contractor's delinquency status.

## 8-9 Default and Termination of Contract.

**8-9.1 Determination of Default:** If the Contractor fails to begin the work under the Contract within the time specified in the "Notice to Proceed," or fails to perform the work with sufficient workmen and equipment or with sufficient materials to assure the prompt completion of the contract, or performs the work unsuitably or neglects or refuses to remove materials or to perform anew such work as may be rejected as unacceptable and unsuitable, or discontinues the prosecution of the work, or fails to resume work which has been discontinued within a reasonable time after notice to do so, or becomes insolvent or is declared bankrupt, or files for reorganization under the bankruptcy code, or commits any act of bankruptcy or insolvency, either voluntarily or involuntarily, or allows any final judgment to stand against him unsatisfied for a period of ten calendar days, or makes an assignment for the benefit of creditors, or fails to comply with contract requirements regarding minimum wage payments or EEO requirements, or for any other cause whatsoever, fails to carry on the work in an acceptable manner, or if the surety executing the bond, for any reasonable cause becomes unsatisfactory in the opinion of the Department, the Engineer will give notice in writing to the Contractor and his surety of such delay, neglect, or default.

If the Contractor, within a period of ten calendar days after the notice described above, shall not proceed to correct the conditions of which complaint is made, the Department shall, upon written certificate from the Engineer of the fact of such delay, neglect or default and the Contractor's failure to correct such conditions, have full power and authority, without violating the contract, to take the prosecution of the work out of the hands of the Contractor and to declare the contract in default.

**8-9.2 Termination of Contract:** The Department may by written notice, with the approval of the Federal Highway Administration where applicable, terminate the Contract or a portion thereof after determining that for reasons beyond either Department or Contractor control, he is prevented from proceeding with or completing the work as originally contracted for, and that termination would therefore be in the public interest. Such reasons for termination may include, but need not be necessarily limited to, executive orders of the President relating to prosecution of war or national defense, national emergency which creates a serious shortage of materials, orders from duly constituted authorities relating to energy conservation, and restraining order or injunctions obtained by third-party citizen action resulting from national or local environmental protection laws or where the



issuance of such order or injunction is primarily caused by acts or omissions of persons or agencies other than the Contractor.

When contracts, or any portion thereof, are terminated before completion of all items of work in the contract, payment will be made for the actual number of units or items of work completed, at the contract unit price, or as mutually agreed for items of work partially completed or not started. No claim for loss of anticipated profits will be considered.

Reimbursement for mobilization expenses (when not otherwise included in the contract) including moving equipment to the job, will be considered where the volume of work completed is too small to compensate the Contractor for these expenses under the contract unit prices; the intent being that an equitable settlement will be made with the Contractor.

Acceptable materials procured by the Contractor for the work, that have been inspected, tested, and approved by the Department, and that are not incorporated in the work, may be purchased from the Contractor at actual cost, as shown by receipted bills and actual cost records, at such points of delivery as may be designated by the Engineer.

Termination of a contract or a portion thereof, under the provisions of this Subarticle, shall not relieve the Contractor of his responsibilities for the completed portion, nor shall it relieve his surety of its obligation for and concerning any just claims arising out of the work performed.

**8-9.3 Completion of Work by Department:** Upon declaration of default the Department will have full power to appropriate or use any or all materials and equipment on the site which are suitable and acceptable, and may enter into an agreement with others for the completion of the work under the contract, or may use other methods which in the opinion of the Engineer are required for the completion of the work in an acceptable manner. All costs and charges incurred by the Department because of the Contractor's default, including the costs of completing the work under the contract, shall be charged against the Contractor. In case the expense so incurred by the Department is less than the sum which would have been payable under the contract if it had been completed by the defaulting Contractor, the defaulting Contractor shall be entitled to receive the difference. In case the expense exceeds the sum which would have been payable under the contract, then the Contractor and the surety shall be liable and shall pay the State the amount of the excess.

If after the ten-day notice period, and prior to any action by the Department to otherwise complete the work under the contract, the Contractor should establish his intent to prosecute the work in accordance with the Department's requirements, the Department may elect to permit the Contractor to resume the work, in which case any costs to the Department incurred by the delay, or from any reason attributable to the delay, will be deducted from any moneys due or which may become due under the contract.





## 8-10 Liquidated Damages for Failure to Complete the Work.

8-10.1 Highway Code Requirements Pertaining to Liquidated Damages: The Florida Highway Code, Section 337.18, paragraph (2), requires that the Department shall adopt regulations for the determination of default and provides that liquidated damages be paid to the Department by the Contractor for any such default. These Code requirements shall govern, and are herewith made a part of the contract.

8-10.2 Amount of Liquidated Damages: Such liquidated damages are established in the following schedule:

| <u>Original Contract Amount</u>         | <u>Daily Charge Per<br/>Calendar Day</u>  |
|---|---|
| \$50,000 and under                      | \$ 50   |
| Over \$50,000 but less than \$250,000   | \$100   |
| \$250,000 but less than \$500,000       | \$200   |
| \$500,000 but less than \$2,500,000     | \$300   |
| \$2,500,000 but less than \$5 million   | \$500   |
| \$5 million but less than \$10 million  | \$750   |
| \$10 million but less than \$15 million | \$1,000   |
| \$15 million but less than \$20 million | \$1,250   |
| \$20 million and over                   | \$1,250 plus<br>5/1000 of 1 percent per day for<br>any amount over \$20 million |

8-10.3 Determination of Number of Days of Default: For all contracts, regardless of whether the contract time is stipulated in calendar days or working days, default days shall be counted in calendar days.

8-10.4 Conditions under which Liquidated Damages are Imposed: Should the Contractor or, in case of his default the surety fail to complete the work within the time stipulated in the contract, or within such extra time as may have been granted by the Department, the Contractor or, in case of his default, the surety shall pay to the Department, not as a penalty but as liquidated damages, the amount so due as determined by the Code requirements, as provided above.

8-10.5 Right of Collection: The Department shall have the right to apply as payment on such liquidated damages any money which is due to the Contractor by the Department.

8-10.6 Permitting Contractor to Finish Work: Permitting the Contractor to continue and to finish the work, or any part of it, after the expiration of the contract time allowed, including extensions of time granted to the Contractor, shall in no way act as a waiver on the part of the Department of the liquidated damages due under the contract.

8-10.7 Completion of Work by Department: In case of default of the contract and the completion of the work by the Department, the Contractor and his surety shall be liable for the liquidated damages under the contract, but no liquidated damages under the contract, but no liquidated damages shall be chargeable for any delay in the final



completion of the work by the Department due to any unreasonable action or delay on the part of the Department.

#### 8-11 Termination of Contractor's Responsibility.

The contract will be considered complete when all work has been completed and has been accepted by the Department. The Contractor will then be released from further obligation except as set forth in his bond, and except as provided in 5-13.





APPENDIX C  
CRITICAL PATH METHOD - ESSENTIAL ELEMENTS AND TECHNIQUES



# CRITICAL PATH METHOD—ESSENTIAL ELEMENTS AND TECHNIQUES

## THE CRITICAL PATH METHOD

During recent years the critical path method of planning, analyzing, and controlling a construction project has become a useful tool for engineers, architects, contractors, and others who are associated with construction. Many government and private agencies require the preparation and use of this method when planning the construction of a project.

In order to analyze a project by using the critical path method it is necessary to divide the project into activities. The number of units of work required to complete each activity should be determined. Then the time required to complete each activity, considering available equipment and labor, should be estimated in appropriate units, such as days, weeks, or months. Also, it is necessary to determine the time sequence in which the activities should be constructed. For example, concrete for a beam can not be placed until the forms have been erected and the reinforcing steel has been placed.

Each activity should be identified by a symbol or an appropriate description or both, and then listed in column form, with the duration of the activity, together with the activities which immediately precede and follow it, given. (This procedure is illustrated in Table 2-1.) Then the interrelationship of the activities can be indicated by a network or arrow diagram, in which each arrow represents an activity. Figure 2-1 illustrates an arrow diagram for a simple project involving five activities, designated by the letters, A, B, C, D, and E, for which the durations are estimated to be 4, 5, 3, 6, and 8 days, respectively.

Activities A and B can be started at the same time. Activities C and D cannot be started until A is completed. Activity E cannot be started until B and C are completed. An examination of Fig. 2-1

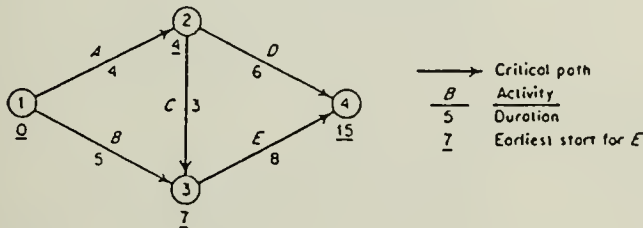


Fig. 2-1 Arrow diagram.

Table 2-1 List of activities, durations, and precedences

| Activity | Duration | Activities which immediately precede | Activities which immediately follow |
|----------|----------|--------------------------------------|-------------------------------------|
| A        | 3        | None                                 | B, C, D                             |
| B        | 5        | A                                    | E                                   |
| C        | 4        | A                                    | F, G                                |
| D        | 6        | A                                    | G, H                                |
| E        | 4        | B                                    | I                                   |
| F        | 5        | C                                    | J                                   |
| G        | 3        | C, D                                 | K                                   |
| H        | 6        | D                                    | L                                   |
| I        | 5        | E                                    | N                                   |
| J        | 7        | F                                    | O                                   |
| K        | 4        | G                                    | P                                   |
| L        | 5        | H                                    | M, Q                                |
| M        | 3        | L                                    | P                                   |
| N        | 4        | I                                    | S                                   |
| O        | 5        | J                                    | S, T                                |
| P        | 6        | K, M                                 | T                                   |
| Q        | 4        | L                                    | R                                   |
| R        | 4        | Q                                    | T                                   |
| S        | 5        | N, O                                 | U                                   |
| T        | 4        | O, P, R                              | U                                   |
| U        | 3        | S, T                                 | None                                |

reveals that the minimum total time required to complete the project is the sum of the durations of activities A, C, and E, which is equal to 15 days. This is the critical path for the network.

If the project illustrated in Fig. 2-1 is modified by eliminating activity C, with the condition that activity E cannot be started until activities A and B are completed, a method must be used to indicate

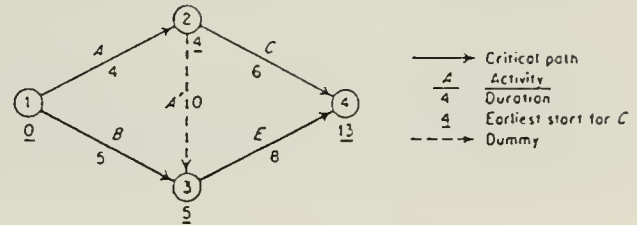


Fig. 2-2 Arrow diagram.

this requirement in the network. Since activity C does not appear in the network, it must be replaced with a dummy arrow, as illustrated in Fig. 2-2. A dummy is not a true activity, and it requires no time for completion. The critical path now lies along activities B and E.

## DEFINITIONS OF TERMS AND SYMBOLS

Because terms and symbols are used in analyzing a project and constructing the arrow diagram, it is necessary to define these items.

**Activity** An activity is the performance of a specific task, such as placing reinforcing steel. It requires time to perform an activity.

**Event** An event represents the completion of an activity. It requires no time in itself. It is usually indicated on the arrow diagram by a number enclosed in a circle.

**Arrow** An arrow is drawn to represent each activity included in the network for a project, joining two events. An arrow is designated by two numbers, one at the tail and one at the head, with the number at the head always larger than the number at the tail. The length of the arrow has no relation to the duration of the activity which it represents.

**Network** This is an arrow diagram drawn to represent the relations of the activities and events. It is common practice to start time and the first arrow or arrows at the left end of the network and to proceed to the right.

**Dummy** A dummy is an artificial activity, represented on the arrow diagram by a dotted line, which indicates that an activity following the dummy cannot be started until the activity or activities preceding the dummy are completed. A dummy activity does not require any time.

**Duration** This is the estimated time, expressed in any desired unit, required to perform an activity.

**Earliest start: ES** This is the earliest time that an activity can be started.

**Earliest finish: EF** This is the earliest time that an activity can be finished. It is the earliest starting time plus the duration of an activity:  $EF = ES + D$ .

**Latest start: LS** This is the latest time that an activity may be started without delaying the completion of a project:  $LS = LF - D$ .

**Latest finish: LF** This is the latest time that an activity can be finished without delaying the completion of a project:  $LF = LS + D$ .

**Total float: TF** This is the amount of time that the start or finish of an activity can be delayed without delaying the completion of a project:  $TF = LF - EF = LS - ES$ . In Fig. 2-1 the earliest time for event 3 is the sum of the durations for activities A and C = 4 + 3 = 7 days. Because activity B has a duration of only 5 days, it can be completed 2 days prior to event 3. Thus its total float is 7 - 5 = 2 days. If the start or finish of activity B is delayed 2 days, it will not delay the completion of the project.

**Free float: FF** This is the amount of time that the finish of an activity can be delayed without delaying the earliest starting time for a following activity.  $FF = ES \text{ (following activity)} - EF \text{ (of this activity)}$ .

**Critical path** The critical path is the series of interconnected activities through the network for which each activity has zero float time. The critical path determines the minimum time required to complete a project.

The uses of these terms and symbols are illustrated more fully in the examples which appear below.



Persons who wish more comprehensive information on this subject may obtain such information from books devoted to the treatment of the critical path method.

#### STEPS IN CRITICAL PATH SCHEDULING

For persons who wish to apply the critical path method of scheduling the construction of a project it is suggested that the following steps be used.

1. Prepare a list of activities for the project.
2. Estimate the duration of each activity.
3. Determine which activity or activities immediately precede each activity.
4. Determine which activity or activities immediately follow each activity.
5. Draw a network with the activities and events properly interconnected.
6. Assign numbers to the events, being sure that the number at the head of each arrow is larger than the number at the tail of the arrow.
7. Prepare a chart with vertical columns and horizontal lines on which to list each activity with an appropriate designation: duration, earliest start, earliest finish, latest start, latest finish, and total float. A column for free float may be included, if this information is desired.
8. Determine which activities lie on the critical path.

#### DEVELOPING A CRITICAL PATH SCHEDULE

The following example illustrates a method of scheduling a project by the critical path method. Table 2-1 illustrates a form that can be used to tabulate the activities, together with the estimated durations, and the activities that immediately precede and follow each activity. Although the activities are designated by letters in this example, it is desirable in actual practice to designate each activity by appropriate descriptive words. Thus this example is intended to demonstrate how an arrow diagram and the related information are developed. This table provides the information specified in steps 1 through 4 of the preceding section.

Steps 5 and 6 are illustrated by Fig. 2-3. In this figure it will be noted that there are four dummies. The dummies  $C'$  and  $D'$  indicate that activities  $C$  and  $D$ , respectively, must be completed before activity  $F$  can be started. If activity  $G$  is drawn directly from event 4, without dummy  $C'$ , it will be necessary to draw dummy  $D'$  from event 5 to event 6. This then will indicate that activity  $F$  cannot be started until activity  $D$  is completed, which is not true. Thus the two dummies  $O'$  and  $O''$  are required for the same reasons.

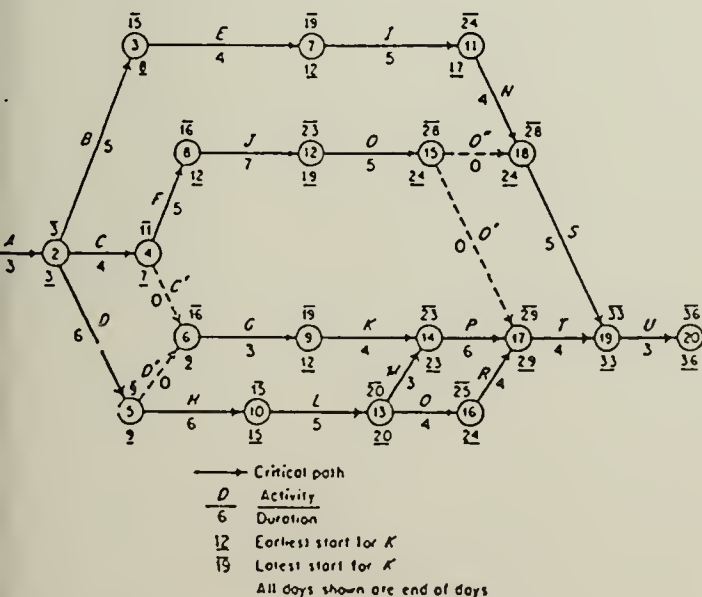


Fig. 2-3. Arrow diagram.

In the figure the heavy lines representing activities  $A$ ,  $D$ ,  $H$ ,  $L$ ,  $M$ ,  $P$ ,  $T$ , and  $U$  lie on the critical path. The estimated time required to complete the project is 36 working days.

Table 2-2 lists the activities, events, durations, starts, finishes, total floats, and free floats. Numbers appearing in the events columns should be taken from the arrow diagram after it is completed and the events numbered thereon.

Perhaps the easiest method of completing this table is to determine and record the earliest start time and finish time for each activity, including the dummies. The earliest start time for an activity is the controlling earliest finish time for the one or more immediately preceding activities. If two preceding activities have earliest finish times of 12

Table 2-2 List of activities and related information

| Activity | Events | D | ES | EF | LS | LF | TF | FF |
|----------|--------|---|----|----|----|----|----|----|
| A*       | 1 2    | 3 | 0  | 3  | 0  | 3  | 0  | 0  |
| B        | 2 3    | 5 | 3  | 8  | 10 | 15 | 7  | 0  |
| C        | 2 4    | 4 | 3  | 7  | 7  | 11 | 4  | 0  |
| C'       | 4 6    | 0 | 7  | 7  | 16 | 16 | 9  | 2  |
| D*       | 2 5    | 6 | 3  | 9  | 3  | 9  | 0  | 0  |
| D'       | 5 6    | 0 | 9  | 9  | 16 | 16 | 7  | 0  |
| E        | 3 7    | 4 | 8  | 12 | 15 | 19 | 7  | 0  |
| F        | 4 8    | 5 | 7  | 12 | 11 | 16 | 4  | 0  |
| G        | 6 9    | 3 | 9  | 12 | 16 | 19 | 7  | 0  |
| H*       | 5 10   | 6 | 9  | 15 | 9  | 15 | 0  | 0  |
| I        | 7 11   | 5 | 12 | 17 | 19 | 24 | 7  | 0  |
| J        | 8 12   | 7 | 12 | 19 | 16 | 23 | 4  | 0  |
| K        | 9 14   | 4 | 12 | 16 | 19 | 23 | 7  | 7  |
| L*       | 10 13  | 5 | 15 | 20 | 15 | 20 | 0  | 0  |
| M*       | 13 14  | 3 | 20 | 23 | 20 | 23 | 0  | 0  |
| N        | 11 18  | 4 | 17 | 21 | 24 | 28 | 7  | 3  |
| O        | 12 15  | 5 | 19 | 24 | 23 | 28 | 4  | 0  |
| O'       | 15 17  | 0 | 24 | 24 | 29 | 29 | 5  | 0  |
| O''      | 15 18  | 0 | 24 | 24 | 28 | 28 | 4  | 0  |
| P*       | 14 17  | 6 | 23 | 29 | 23 | 29 | 0  | 0  |
| Q        | 13 16  | 4 | 20 | 24 | 21 | 25 | 1  | 0  |
| R        | 16 17  | 4 | 24 | 28 | 25 | 29 | 1  | 1  |
| S        | 18 19  | 5 | 24 | 29 | 28 | 33 | 4  | 4  |
| T*       | 17 19  | 4 | 29 | 33 | 29 | 33 | 0  | 0  |
| U*       | 19 20  | 3 | 33 | 36 | 33 | 36 | 0  | 0  |

\* These activities are on the critical path.

NOTE: All days shown are the ends of days.

and 16 days, respectively, the 16 days will determine the earliest start time for the following activity.

After the minimum time required to construct the project is determined, 36 days for this project, the latest finish times for each activity can be determined by working backward from the 36 days. For example, the latest finish times for activities  $S$  and  $T$  are determined by subtracting the duration of activity  $U$ , namely 3 days, from 36 to give 33 days. The latest start time for activity  $S$  is its latest finish time minus the duration of  $S$ , namely 5 days, to give a value of 28 days. This procedure is applied along each path of activities.

The symbol 19 appearing under event 12 in Fig. 2-3 indicates that 19 days is the earliest finish time for activity  $J$  and the earliest start time for activity  $O$ . The symbol 23 appearing above event 12 indicates that 23 days is the latest finish time for activity  $J$  and the latest start time for activity  $O$ .

#### DETERMINING TOTAL FLOAT

The total float of an activity is the number of days or other appropriate units of time that the start or finish of an activity may be delayed without delaying the completion time for the overall project. Referring to Fig. 2-3 it will be noted that the earliest finish date for activity  $B$  is the end of the eighth day, while the latest finish time is the end of the fifteenth day. Thus there is a leeway of  $15 - 8 = 7$  days for completing activity  $B$ . This is the total float designated in Table 2-2. The total float of 7 days may be allocated to any one of the activities along the path  $B$ ,  $E$ ,  $I$ ,  $N$ , or it may be allocated in parts to more than one activity, provided the total delays do not exceed 7 days.





APPENDIX D  
SUMMARY OF CONTRACT TIME DETERMINATION - MISSISSIPPI



## SUMMARY OF CONTRACT TIME DETERMINATION—MISSISSIPPI

The Mississippi State Highway Department uses a progress schedule (bar chart) both to establish and to charge contract time. The progress schedule is published in the proposal so that a bidder can identify the items and rates of work that were considered in determining the time and thus reasonably estimate resources; i.e., personnel, equipment, etc., required to complete the work within the allotted time.

The progress schedule is developed by applying production parameters to the contract work items. Allied or similar work items are grouped into phases that are positioned on a bar chart in logical sequence. The positioning allows for mobilization and transition among the various phases. Additionally, applicable seasonal limitations are taken into consideration. The resulting chart indicates the number of productive days (termed time units) that are considered necessary for the work.

Contracts are let on a completion-date basis. To establish the completion date, a monthly allotment of time units is used (see Table E-1). This table was formulated by a review of monthly contractor estimates for the various types of projects and is indicative of the contractors' ability to earn money in any given month according to previous performance.

These monthly divisions are graphically indicated on the bar chart form. The work phase bars are entered on the chart in their proper calendar position oriented to the beginning of construction date. The end result after positioning the bars establishes the specified completion date.

As previously stated, the contracts are let on a completion-date basis. However, in recognition that abnormal weather conditions may occur within the life of a contract that could prevent the timely completion of the work, the contractor is guaranteed access to the number of time units determined by the state as necessary to do the work. If, on the completion date, the contractor has not been afforded the time units, the contract is automatically extended daily until the required time units have occurred.

The progress schedules govern the daily assessment of

contract time and, as uniformity is vital, they are all prepared in the central office of the Construction Division where consistent oversight can be more easily exercised.

It is recognized that the actual management of a project rests with the contractor. In order not to mandate the sequence of operations, the contractor is given the option of either accepting the state's progress schedule or submitting his own. He may not, however, modify the specified completion date.

Examples of production parameters, a progress schedule that shows the grouping of work items into phases and bar interrelationships, and instructions relative to the daily time assessments follow.

TABLE E-1  
TIME UNITS

| MONTH         | COLUMN<br>A | COLUMN<br>B | COLUMN<br>C | COLUMN<br>D |
|---------------|-------------|-------------|-------------|-------------|
| January       | 5           | 5           | 6           | 7           |
| February      | 5           | 6           | 7           | 8           |
| March         | 9           | 9           | 11          | 13          |
| April         | 13          | 14          | 14          | 17          |
| May           | 17          | 19          | 19          | 19          |
| June          | 19          | 20          | 22          | 19          |
| July          | 21          | 22          | 23          | 18          |
| August        | 21          | 22          | 23          | 18          |
| September     | 20          | 20          | 22          | 17          |
| October       | 15          | 17          | 17          | 15          |
| November      | 10          | 11          | 11          | 12          |
| December      | 5           | 5           | 5           | 7           |
| Calendar Year | 160         | 170         | 180         | 170         |

Column A: Grading and Drainage Projects

Column B: Base and Paving Projects

Column C: Bridge or Specialized Projects

Column D: Widening and Overlay (Asphalt) Projects



# PRODUCTION PARAMETERS

|     |                   | Small<br>Projects<br>0-750 M       | Medium<br>Projects<br>750-1, 500 M | Large<br>Projects<br>1,500 M-Greater | Overlay<br>Projects   |
|-----|-------------------|------------------------------------|------------------------------------|--------------------------------------|-----------------------|
| 1.  | Mob.              | 10 TU                              | 12 TU                              | 14 TU                                | 15 TU                 |
| 2.  | C & G             | 5 TU (lead)                        | 8 TU (lead)                        | 10 TU (lead)                         |                       |
| 3.  | Small Struct.     | 5 TU (lead)                        | 8 TU (lead)                        | 10 TU (lead)                         |                       |
| 4.  | Unclass. Exc.     | 2500-400 CY/TU                     | 3500-600 CY/TU                     | 6000-12000 CY/TU                     |                       |
| 5.  | Embankment (CF)   | 1500-3000 CY/TU                    | 2000-3500 CY/TU                    | 2500-5000 CY/TU                      |                       |
| 6.  | In-Gr. Mod.       | 10000 SY/TU                        | 10000 SY/TU                        | 10000 SY/TU                          |                       |
| 7.  | Lime Treat A      | 8000 SY/TY (+20 TU)                | 8000 SY/TU (+20 TU)                | 8000 SY/TU (+20 TU)                  |                       |
| 8.  | Lime Treat B      | 8000 SY/TU (+20 TU)                | 8000 SY/TU (+20 TU)                | 8000 SY/TY (+20 TU)                  |                       |
| 9.  | Lime Treat C      | 10000 SY/TU                        | 10000 SY/TU                        | 10000 SY/TU                          |                       |
| 10. | Lime Treat D      | 15000 SY/TU                        | 15000 SY/TU                        | 15000 SY/TU                          |                       |
| 11. | Cement Treat      | 8000 SY/TU                         | 8000 SY/TU                         | 8000 SY/TU                           |                       |
| 12. | Gran. Mat. (CF)   | 1000-2000 CY/TU                    | 1500-2500 CY/TU                    | 2000-3000 CY/TU                      |                       |
| 13. | Top Soil          | 500 CY/TU                          | 1000 CY/TU                         | 1500 CY/TU                           |                       |
| 14. | Plating Mat.      | 500 CY/TU                          | 1000 CY/TU                         | 1500 CY/TU                           |                       |
| 15. | EC                | 22,200 SY/TU                       | 39,000 SY/TU                       | 56,000 SY/TU                         | 0.5 MI/TU             |
| 16. | HB Base           | 700 Tons/TU                        | 850 Tons/TU                        | 1000 Tons/TU                         | 700 Tons/TU           |
| 17. | HB Leveling       |                                    |                                    |                                      | 500 Tons/TU           |
| 18. | Trench & Widen    |                                    |                                    |                                      | 1 Mile ea. side/TU    |
| 19. | Grout. Slabs      |                                    |                                    |                                      | 150-300 holes/TU      |
| 20. | Rem. RCP          |                                    |                                    |                                      | 250 SY/TU             |
| 21. | Clean & Seal Jts. |                                    |                                    |                                      | 2000 FT/TU            |
| 22. | Prelim. Rolling   |                                    |                                    |                                      | 2 MI/TU               |
| 23. | HB Binder         | 700 Tons/TU                        | 700 Tons/TU                        | 850 Tons/TU                          | 700 Tons/TU           |
| 24. | HB Surface        | 500 Tons/TU                        | 500 Tons/TU                        | 700 Tons/TU                          | 500 Tons/TU           |
| 25. | DBST              | 0.5 MI/TU (2 Lane)                 | 0.5 MI/TU (2 Lane)                 | 0.5 MI/TU (2 Lane)                   | 0.5 MI/TU (2 Lane)    |
| 26. | SBST              | 1.0 MI/TU (2 Lane)                 | 1.0 MI/TU (2 Lane)                 | 1.0 MI/TU (2 Lane)                   | 1.0 MI/TU (2 Lane)    |
| 27. | Sho. Mat.         |                                    |                                    |                                      | 500 CY/TU             |
| 28. | RC Curb           | 100 FT/TU (min. 5 TU)              | 200 FT/TU (min. 5 TU)              | 300 FT/TU (min. 5 TU)                | 100 FT/TU (min. 5 TU) |
| 29. | HB Curb           | 500 FT/TU                          | 500 FT/TU                          | 500 FT/TU                            | 500 FT/TU             |
| 30. | Curb & Gutter     | 100 FT/TU (min. 5 TU)              | 200 FT/TU (min. 5 TU)              | 300 FT/TU (min. 5 TU)                | 100 FT/TU (min. 5 TU) |
| 31. | Traffic Stripe    | 4 MI (of stripe)/TU<br>(min. 5 TU) | 4 MI/TU (min. 5 TU)                | 4 MI/TU (min. 5 TU)                  | 2 MI/TU (min. 5 TU)   |
| 32. | Detail Stripe     | 2000 FT/TU                         | 2000 FT/TU                         | 2000 FT/TU                           | 2000 FT/TU            |
| 33. | Legend Paint      | 500 SF/TU                          | 500 SF/TU                          | 500 SF/TU                            | 500 SF/TU             |
| 34. | Conc. Base        | 5000 SY/TU                         | 8000 SY/TU                         | 8000 SY/TU                           |                       |
| 35. | CP (Plain)        | 5000 SY/TU                         | 8000 SY/TU                         | 8000 SY/TU                           |                       |
| 36. | RCP               | 5000 SY/TU                         | 8000 SY/TU                         | 8000 SY/TU                           |                       |
| 37. | CRCP              | 5000 SY/TU                         | 8000 SY/TU                         | 8000 SY/TU                           |                       |





HORIZONTAL SCALE-1"=20 TIME UNITS  
REVISED DUE TO LATE NOTICE TO PROCEED











# DAILY REPORT OF TIME UNIT ASSESSMENT

## EXAMPLE

| Work Phase      |                        |             | Ratio<br>to<br>Daily<br>Total<br>(5) | (6)<br>Work<br>Condition |      | (7)<br>Hours<br>Worked | Productive<br>Hours<br>Available<br>(8) | Adjusted<br>Productive<br>Hours<br>(9) |   |
|-----------------|------------------------|-------------|--------------------------------------|--------------------------|------|------------------------|---|--|---|
| (1)<br>No.      | (2)<br>Description     | (3)<br>AVTU |                                      | Sat.                     | Uns. |                        |   |  |   |
| 2               | Excavation             | 5,935       | .55                                  | X                        |      | 4                      | 4                                       | 2.2                                    |   |
| 3               | Granular Mat'l & Prime | 3,030       | .28                                  | X                        |      | 7                      | 8                                       | 2.2                                    |   |
| 5               | Minor Dr Str, Etc      | 1,429       | .13                                  | X                        |      | 10                     | 10                                      | 1.3                                    |   |
| 8               | Erosion Control Items  | 392         | .04                                  | X                        |      | 0                      | 8                                       | 0.3                                    |   |
|                 |                        |             |                                      |                          |      |                        |   |  |   |
|                 |                        |             |                                      |                          |      |                        |   |  |   |
| Daily Total (4) |                        | 10,786      |                                      |                          |      |                        | (10)                                    | 6.0                                    | 0.7* (11)                                   |
|                 |                        |             |                                      |                          |      |                        |   |  | +8=   |
|                 |                        |             |                                      |                          |      |                        |   |  | +   |
|                 |                        |             |                                      |                          |      |                        |   |  | Previously Assessed Time Units 69.9         |
|                 |                        |             |                                      |                          |      |                        |   |  | Cumulative Time Units Assessed To Date 70.6 |

- (1) This is a list of all the controlling phases of work that should be in progress on the date shown. The phase numbers are as they are shown on the Progress Schedule.
- (2) This is a plain language description of each phase, also from the Schedule.
- (3) This is the Average Value per Time Unit (AVTU) to the closest dollar for the phases shown. This value is determined by dividing the total value of all contract items in a phase by the total number of time units allotted to the phase.
- (4) This is the AVTU total for all phases that should be in progress this day.
- (5) This is the ratio of the individual AVTU to the total-- (3)+(4).
- (6) These columns are where the Project Engineer must exercise unbiased judgement when making entries. If soil and weather conditions are satisfactory for any part of the day, enter an X under Sat. by each of the phases for which conditions were satisfactory for work even if for only part of the day. If conditions were unsatisfactory during the entire day, enter an X under Uns.
- (7) This column is self-explanatory, it is the hours actually worked on a phase.
- (8) This is another column where the Project Engineer must depend upon his judgement to make an entry. It shows the total number of productive hours that the Contractor could work on each phase. The hours for each phase should not exceed 8 unless the Contractor actually worked more than 8 hours. If he works more than 8 productive hours, the entry is to be the hours actually worked. If the productive hours available are shown to be less than the hours worked, the Project Engineer should make a note of explanation on the front sheet of the diary.
- (9) This column shows the adjusted productive hours for each phase. The adjusted productive hours for each phase is determined by multiplying the ratio under (5) by the productive hours available shown under (8).
- (10) This figure is the total Adjusted Productive Hours for the day or the sum of the Adjusted Productive Hours for each phase.
- (11) This figure is the number of time units to charge for the day. It is the quotient of (10) ÷ 8. For contracts awarded in and after June 1975, this figure is not to exceed 1.0 time unit per day.

\* Round down to nearest tenth



APPENDIX E  
CONTRACT TIME DETERMINATION - WYOMING





# CONTRACT TIME DETERMINATION—WYOMING

After completion of contract plans and determination of a letting date, the Highway Department determines the contract date of completion using the critical path method.

Contract time is determined independently by two individuals. Production factors and anticipated adverse weather days are considered. The critical path is based on expectations of the contractor's work methods. The time determina-

tion (contract completion date) of each analysis is reviewed by a staff engineer who compares the analyses, reconciles any differences, and determines the contract completion dates to be used in the contract documents.

Two independent analyses, the engineer's review, and the final time determination on a construction project in Wyoming are presented here.

## CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1 (27)

Letting Date July 11, 1980

Road - KEMMERER By-Pass

Award Date July 19, 1980

County - LINCOLN

Starting Date AUGUST 18, 1980

Determination Made by AL TOOKER

Date MAY 30, 1980

| <u>Node</u>           | <u>Description</u>                                   | <u>Working Days</u> |
|-----------------------|--|---------------------|
| 1-2                   | MOBILIZATION   | 10                  |
| 2-4                   | STRIPPING PITS 58,000 C.Y. @ 3500 C.Y./day           | 17                  |
| 2-3                   | CRUSHING MTL. 278,860 TONS @ 2500 T./day             | 112                 |
| 2-5 = 10<br>5-6 = 122 | UNCL. EXCL. 2,373,200 C.Y. @ 18,010 C.Y./day         | 122 132             |
| 6-7                   | CRUSHER RUN SUB-BASE 163,600 TONS @ 5100 T./day      | 32                  |
| 7-8                   | CR. BASE 72,000 TONS @ 2500 T./day                   | 29                  |
| 9-10                  | H.P. MIX BIT. PMT., TYPE I 44,100 TONS @ 2000 T./day | 20                  |
| 10-11                 | P.M. WEARING COURSE, TYPE A 6425 TONS @ 1300 T./day  | 4                   |
| 8-9                   | CONCRETE PMT. 7400 Sq Yds. @ 1500 Sq Yd./day         | 5                   |
| 2-20                  | PIPE CULVERTS 18" to 60" 4420 L.F. @ 150 L.F./day    | 30                  |
|                       | C.M.P. 24" 154 L.F. @ 150 L.F./day                   | 30                  |
| 12-26                 | GUARD RAIL, BOX BEAM 1032 L.F. @ 300 L.F./day        | 3                   |
| 21-22                 | FENCE, 32" WW 2 BW 32,000 L.F. @ 1800 L.F./day       | 21                  |
| 20-21                 | CATTLEGUARDS, 16' 2-EACH @ 2-days EA.                | 4                   |
|                       |  |                     |
|                       |  |                     |
|                       |  |                     |



# CONTRACT TIME DETERMINATION

District 3

Project - SCPF--012-1(27) Letting Date July 11, 1980  
 Road - KEMMERER By-Pass Award Date July 19, 1980  
 County - LINCOLN Starting Date August 18, 1980

Determination Made by AL TOOKER Date May 30, 1980

Node                      Description                      Working Days

|       |  |    |
|-------|--|----|
|       | <u>SIGN STRUCTURE &amp; SIGN LIGHTING — 2-LOCATIONS</u>        |    |
| 10-25 | <u>DRILLED SHAFT FOUNDATIONS, 30" 100 L.F. @ 50 L.F./day</u>   | 2  |
|       | <u>- STR. STEEL DELIVERY TIME - 4 MONTHS = DEC. 18, 1980 -</u> |    |
| 11-12 | <u>SET STR. STEEL 2-LOCATIONS @ 5-days EA.</u>                 | 10 |
| 12-13 | <u>SIGN LIGHTING, ELECTRICAL CONNECTIONS, ETC.</u>             | 5  |
| 14-15 | <u>PAINT STR. STEEL</u>  | 5  |

|       |  |    |
|-------|--|----|
|       | <u>STEEL BREAK-AWAY SIGNS — 7-LOCATIONS</u>                                |    |
| 23-24 | <u>DRILLED SHAFT FOUNDATIONS, 24" 112 L.F. @ 50 L.F./day</u>               | 2  |
|       | <u>- STR. STEEL DELIVERY TIME - 4 Mos. = 12-18-80 -</u>                    |    |
|       | <u>SET STR. STEEL &amp; SIGN INSTALLATIONS 7-LOCATIONS @ 2-days EA. 14</u> | 16 |

|      |   |    |
|------|---|----|
|      | <u>ROADWAY LIGHTING SYSTEM —</u>                                  |    |
| 5-23 | <u>DRILLED SHAFT FOUNDATIONS, 30" 104 L.F. @ 50 L.F./day</u>      | 2  |
|      | <u>PULL BOXES, CONCRETE 25 EACH @ 5 per day</u>                   | 5  |
|      | <u>TRENCHING &amp; BACKFILLING 4000 L.F. @ 300 L.F./day</u>       | 13 |
|      | <u>SERVICE POINTS 3-EACH @ 1 per day</u>                          | 3  |
|      | <u>- DELIVERY TIME - STEEL STDS. - 6 MONTHS = FEB. 18, 1981 -</u> |    |
|      | <u>STEEL STDS., TYPE II 13-EACH @ 2 per day</u>                   | 7  |
|      | <u>ELECTRICAL CONNECTIONS, ETC.</u>                               | 10 |



# CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date JULY 11, 1980  
 Road - KEMMEKER BY-PASS Award Date JULY 19, 1980  
 County - LINCOLN Starting Date AUGUST 18, 1980

Determination Made by AL TOOKER Date MAY 30, 1980

Node      Description      Working Days

|       |   |                                  |                         |
|-------|---|----------------------------------|-------------------------|
|       | <u>STRUCTURE - STA. 76+44.39 - U.S. 30 By Pass</u>          |                                  | <u>215' b-b Abut's.</u> |
|       | <u>ABUT. 1 -</u>  |                                  |                         |
|       | <u>SPREAD FOOTINGS (4-EA)</u>                               | <u>Form = 4 }<br/>Pour = 2 }</u> | <u>6</u>                |
|       | <u>COLUMNS (4-EA)</u>                                       | <u>Form = 4 }<br/>Pour = 2 }</u> | <u>6</u>                |
|       | <u>CAP</u>  | <u>Form = 3 }<br/>Pour = 1 }</u> | <u>4</u>                |
|       | <u>WALL &amp; WING WALLS</u>                                | <u>Form = 6 }<br/>Pour = 3 }</u> | <u>9</u>                |
|       | <u>ABUT. 2 -</u>  |                                  |                         |
|       | <u>STEEL PILING HP 10 x 42 43# L.F. @ 75 L.F./day</u>       |                                  | <u>6</u>                |
|       | <u>CAP</u>  | <u>Form = 3 }<br/>Pour = 1 }</u> | <u>4</u>                |
| 5-18  | <u>WALL &amp; WING WALLS</u>                                | <u>Form = 6 }<br/>Pour = 3 }</u> | <u>9</u>                |
|       | <u>BENT 1 -</u>   |                                  |                         |
|       | <u>FOOTINGS (3-EA)</u>                                      | <u>Form = 3 }<br/>Pour = 1 }</u> | <u>4</u>                |
|       | <u>COLUMNS (3-EA)</u>                                       | <u>Form = 6 }<br/>Pour = 3 }</u> | <u>9</u>                |
|       | <u>CAP</u>  | <u>Form = 4 }<br/>Pour = 1 }</u> | <u>5</u>                |
|       | <u>BENT 2 -</u>   |                                  |                         |
|       | <u>FOOTINGS (3-EA)</u>                                      | <u>Form = 3 }<br/>Pour = 1 }</u> | <u>4</u>                |
|       | <u>COLUMNS (3-EA)</u>                                       | <u>Form = 6 }<br/>Pour = 3 }</u> | <u>9</u>                |
|       | <u>CAP</u>  | <u>Form = 4 }<br/>Pour = 1 }</u> | <u>5</u>                |
|       | <u>STR. STEEL DELIVERY = 6 MONTHS = FEBRUARY 18, 1981 -</u> |                                  |                         |
|       | <u>SET STR. STEEL - 7-GIRDERS @ 2-days EA.</u>              |                                  | <u>14</u>               |
|       | <u>DECK &amp; CURBS</u>                                     | <u>Form = 20<br/>Pour = 1</u>    | <u>21</u>               |
| 18-19 | <u>STRIP DECK FORMS</u>                                     |                                  | <u>5</u>                |
|       | <u>APPROACH SLABS</u>                                       | <u>Form = 2 }<br/>Pour = 2 }</u> | <u>4</u>                |
|       | <u>BR. RAILING 487 L.F. @ 100 L.F./day</u>                  |                                  | <u>5</u>                |
|       | <u>SLOPE PAVING 1820 Sq.yds. @ 150 Sq.yd./day</u>           |                                  | <u>12</u>               |
|       | <u>PAINT - STR. STEEL</u>                                   |                                  | <u>14</u>               |





# CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date July 11, 1980  
 Road - KEMMERER By-Pass Award Date July 19, 1980  
 County - LINCOLN Starting Date August 18, 1980

Determination Made by AL TOOKER Date May 30, 1980

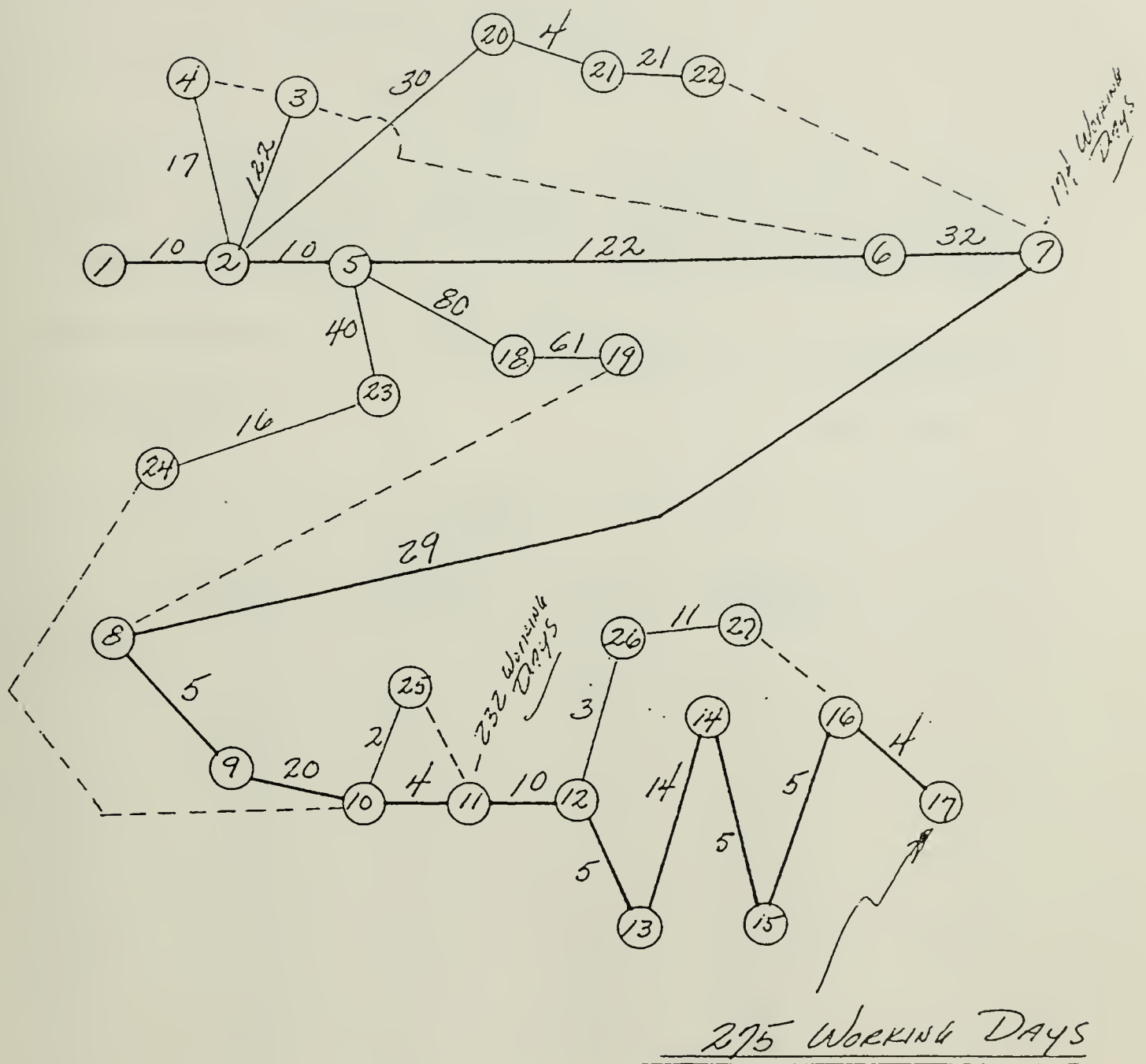
Node                      Description                      Working Days

|       |   |    |
|-------|---|----|
| 15-16 | OLD ROAD OBLITERATION 2.3 MILES @ 0.5 Mi/day                | 5  |
| 26-27 | SEEDING (PLS) 2915 Lbs. @ 11 Lbs./Ac. = 265 Ac. @ 25 A./day | 11 |
| 16-17 | MISC. & CLEANUP WORK  | 4  |

672







### STAFF REVIEW & COMMENTS:

Adjust production rate on grading to 25,000 c.y./day for last 2.2 million yds. so node 5-6 is 88 working days. Parallel 16 days of crusher run subbase. Working days will be reduced to  $275 - 40 - 16 = 219$  JSL



# CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date July 11, 1980  
 Road - KEMMERER By-Pass Award Date July 19, 1980  
 County - LINCOLN Starting Date AUGUST 18, 1980

Determination Made by AL TOOKER Date MAY 30, 1980

Node      Description      Working Days

|              |            | <u>DAYS</u> |                |               |              |
|--------------|------------|-------------|----------------|---------------|--------------|
|              |            | <u>WORK</u> | <u>WEATHER</u> | <u>AVAIL.</u> | <u>ACCU.</u> |
| <u>1980-</u> | <u>AUG</u> | <u>10</u>   | <u>1</u>       | <u>9</u>      |              |
|              | <u>SEP</u> | <u>19</u>   | <u>4</u>       | <u>15</u>     | <u>24</u>    |
|              | <u>OCT</u> | <u>22</u>   | <u>7</u>       | <u>15</u>     | <u>39</u>    |
|              | <u>NOV</u> | <u>20</u>   | <u>10</u>      | <u>10</u>     | <u>49</u>    |
| <u>1981-</u> | <u>APR</u> | <u>22</u>   | <u>8</u>       | <u>14</u>     | <u>63</u>    |
|              | <u>MAY</u> | <u>21</u>   | <u>6</u>       | <u>15</u>     | <u>78</u>    |
|              | <u>JUN</u> | <u>21</u>   | <u>4</u>       | <u>17</u>     | <u>95</u>    |
|              | <u>JUL</u> | <u>22</u>   | <u>2</u>       | <u>20</u>     | <u>115</u>   |
|              | <u>AUG</u> | <u>21</u>   | <u>2</u>       | <u>19</u>     | <u>134</u>   |
|              | <u>SEP</u> | <u>21</u>   | <u>4</u>       | <u>17</u>     | <u>151</u>   |
|              | <u>OCT</u> | <u>22</u>   | <u>7</u>       | <u>15</u>     | <u>166</u>   |
|              | <u>NOV</u> | <u>17</u>   | <u>10</u>      | <u>7</u>      | <u>173</u>   |
| <u>1982-</u> | <u>APR</u> | <u>22</u>   | <u>8</u>       | <u>14</u>     | <u>187</u>   |
|              | <u>MAY</u> | <u>20</u>   | <u>6</u>       | <u>14</u>     | <u>201</u>   |
|              | <u>JUN</u> | <u>22</u>   | <u>4</u>       | <u>18</u>     | <u>219</u>   |
|              | <u>JUL</u> | <u>22</u>   | <u>2</u>       | <u>20</u>     | <u>239</u>   |
|              | <u>AUG</u> | <u>21</u>   | <u>2</u>       | <u>19</u>     | <u>258</u>   |
|              | <u>SEP</u> | <u>21</u>   | <u>4</u>       | <u>17</u>     | <u>275</u>   |

Use July 31, 1982 gse  
 CONTRACT COMPLETION DATE = SEPTEMBER 30, 1982

AL Tooker 5-30-80



# CONTRACT TIME DETERMINATION

District 3

Project - ICPF 012-1(27) Letting Date 7-11-80  
 Road - Kemmerer Bypass Award Date 7-19-80  
 County - LINCOLN Starting Date 8-18-80

Determination Made by Paul Gruethrich Date 5-30-80

| <u>Node</u>   | <u>Description</u>                           | <u>Working Days</u> |
|---------------|--|---------------------|
| 1-2           | Mobilization                                 | 10                  |
| 3-4           | Stripping - 58000 cy - 3000/day              | 19                  |
| 3-5           | Crushing - 285000 Ton - 3000/day             | 95                  |
| 2-2a<br>2a-11 | Uncl. Exc. - 2373200 cy - 15000/day          | 158                 |
| 2-7           | Pipe - 4644 L.F. - 200/day                   | 23                  |
| 2-8           | Fence - 37000 L.F. - 200/day                 | 19                  |
| 2-9<br>6-10   | Gr. Run Sub-Base - 163600 Ton - 5000/day     | 54                  |
| 10-12         | Gr. Base - 72000 Ton - 3000/day              | 24                  |
| 12-13         | Conc. Pmt - 7400 sq yd - 1800/day            | 4                   |
| 12-14         | HPMB Pmt - 40100 Ton - 2500/day              | 16                  |
| 14-15         | PMWC - 6425 Ton - 1300/day                   | 5                   |
| 14-16         | Gr. Rail-Box Beam - 1032 L.F. - 400/day      | 3                   |
| 15-17         | Standards - 13 ea - 2/day                    | 7                   |
|               | Str. Steel (Overhead Signs) - 2 ea - 1/day   | 2                   |
| 14-18         | Str. Steel (Breakaway Signs) - 7 ea - 10/day | 1                   |
| 18-19         | Painting Overhead Signs - 2 ea - 1/day       | 2                   |
| 19-20         | Haul Road Restoration                        | 2                   |
| 20-21         | Lighting System - Final Hook-up              | 2                   |
| 17-22         | Seeding - 2915 lbs - 265 acres - 40/day      | 7                   |
| 22-23         | Testing & Misc. Clean-up                     | 10                  |
|               |  | 463                 |
|               | 6 mos. delivery - Str Steel                  |                     |
|               | 6 mos. delivery - Light Stds                 |                     |
|               | 4 mos. delivery - Sign Str                   |                     |





# CONTRACT TIME DETERMINATION

District 3

Project - SCPF-012-1(27) Letting Date 7-11-80  
 Road - Kemmerer By-Pass Award Date 7-19-80  
 County - LINCOLN Starting Date 8-18-80

Determination Made by Paul Dietrich Date 5-30-80

Node                      Description                      Working Days

Bridge - Sta. 76+44.39

|       |   |    |
|-------|---|----|
| 2a-11 | Dry Exc.                                  | 1  |
| 11-25 | Drive Piling - 434 L.F. - 80/day          | 5  |
| 24-26 | Form & Pour Abut #1                       | 8  |
| 11-24 | Form & Pour Abut #2                       | 7  |
| 26-27 | Form & Pour Bent #1                       | 7  |
| 26-28 | Form & Pour Bent #2                       | 7  |
| 29-30 | Set Girders - Teq 1/day                   | 7  |
| 30-31 | Form & Pour Deck                          | 20 |
| 27-29 | Paint Slope Paving - 1820 sq yd - 200/day | 9  |
| 31-32 | Strip Deck                                | 6  |
| 32-33 | Appr. Slabs - 2 days/ea                   | 4  |
| 32-34 | Br. Paving - 487 LF - 150/day             | 3  |
| 32-35 | Paint Girders - Teq. 1/day                | 7  |
|       | Misc. & Clean-up                          | 5  |
|       |   | 96 |

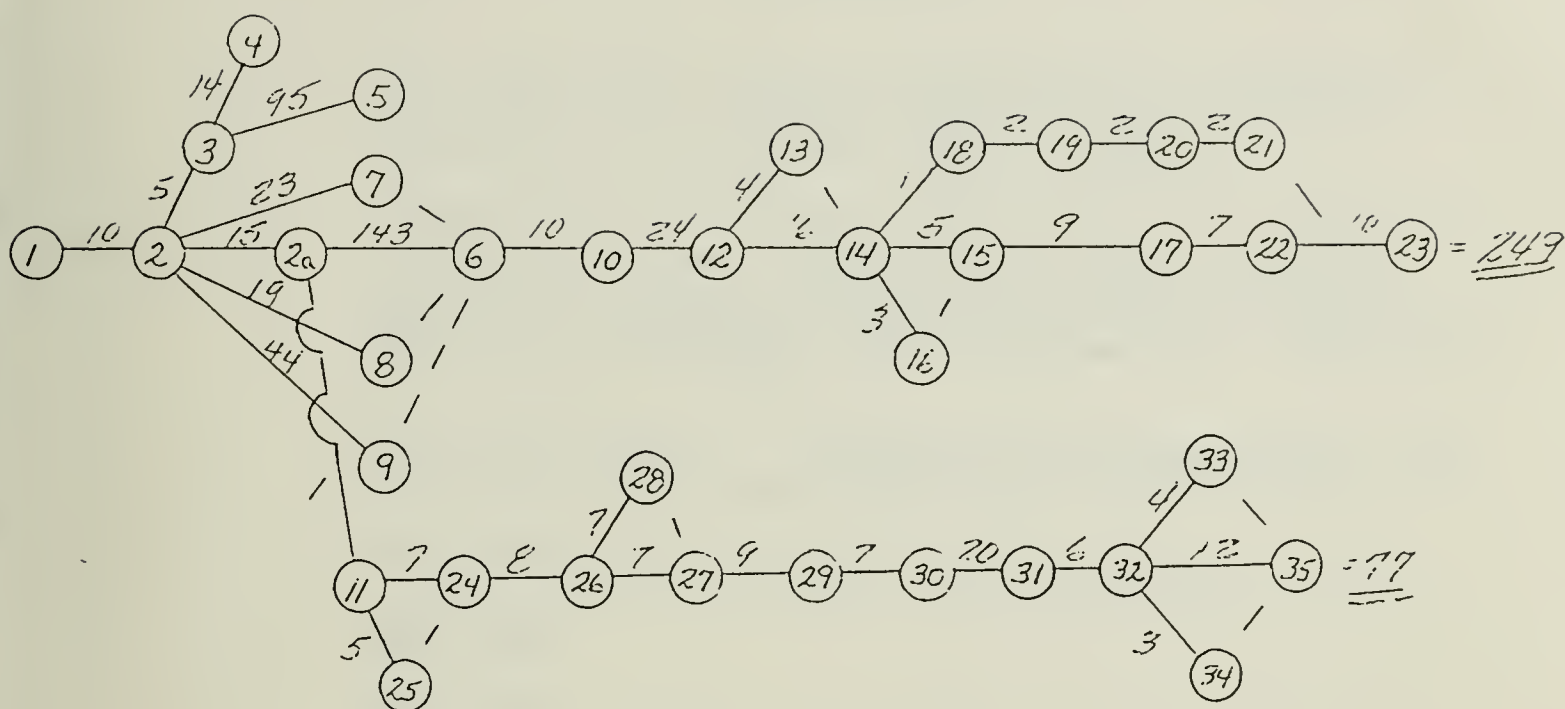
12

Total Working Days 559

Staff Review & Comments

Reduce grading to 88 working days.  
 Increase activity 6-10 paralleling only 1/2 of  
 the crusher run subbase. Working days =  
 249-70+17 = 196 working days HSE





| Month | Work | Weather | Available | Accumulative |
|-------|------|---------|-----------|--------------|
| Aug   | 10   | 1       | 9         | 9            |
| Sep   | 19   | 4       | 15        | 24           |
| Oct   | 22   | 7       | 15        | 39           |
| Nov   | 20   | 10      | 10        | 49           |
| Apr   | 22   | 8       | 14        | 63           |
| May   | 21   | 6       | 15        | 78           |
| Jun   | 21   | 4       | 17        | 95           |
| Jul   | 22   | 2       | 20        | 115          |
| Aug   | 21   | 2       | 19        | 134          |
| Sep   | 21   | 4       | 17        | 151          |
| Oct   | 22   | 7       | 15        | 166          |
| Nov   | 17   | 10      | 7         | 173          |
| Apr   | 22   | 8       | 14        | 187          |
| May   | 20   | 6       | 14        | 201          |
| Jun   | 22   | 4       | 18        | 219          |
| Jul   | 22   | 2       | 20        | 239          |
| Aug   | 21   | 2       | 19        | 258          |

Completion Date = Use July 31, 1982, <sup>asc</sup>  
August 31, 1982



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